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CLUSTER PARAMETER ANALYSIS SYSTEMS.(U)

JUL 66 W J WILSTERMAN

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ABSTRACT

This memorandum is the documentation on a set of digital computer programs which are called Cluster Parameter Analysis Systems. The purpose of these programs is to research the possibility of using techniques in sonar research programming to distinguish target data from non-target data other than the techniques which are now in use. The data used in developing these program analysis systems was initially collected at sea by the LORAD system. The LORAD system described in NEL Report 1060 is primarily an active sonar system. (However, results of this study may find application in the general area of computer-aided detection of sonar echoes.) The clusters herein referred to consist of sets of two or more acoustic data words and are caused by sonar echoes from targets or by target-like echo events.

This technical memorandum has been prepared because it is believed that the information contained herein will be of interest to others at NEL. The views expressed are those of the author and do not necessarily represent those of the laboratory. Distribution outside the laboratory will be limited.

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CLUSTER PARAMETER ANALYSIS SYSTEMS

OBJECTIVE OF CLUSTER PARAMETER ANALYSIS SYSTEMS

The objective of cluster parameter analysis systems is to research the feasibility of distinguishing target from noise returns in programming acoustic research on a basis differing from the technique which is now in use. The technique now in use is the confidence level threshold technique. The confidence level of each cluster is computed by taking the sum of the amplitudes of the words of a cluster. This value is then compared to a reference or threshold value, and, if the confidence level is above or equal to the reference value, the classification rendered is that of target; if below the reference point, the classification rendered is that of non-target. This then basically is the thresholding technique as applied to one parameter. It is seen as possible that the confidence level of a cluster may exceed that of a reference value and not be a true target, while that of a true target may not exceed the reference value. A cluster whose confidence level exceeds the reference value but is not a true target is defined to be a false alarm. A target cluster whose confidence level does not exceed or equal the reference value is defined to be an undetected target. Thus, in the analysis of any data on the basis of some sort of thresholding technique, corresponding to each reference value, there will be a number of false alarms and detected targets, non-targets, and undetected targets. The objective of the thresholding technique is to optimize the number of targets detected while minimizing the number of false alarms. By taking a low reference value, we can optimize the detection of targets, but in general by lowering the reference value, we will get more false alarms. On the other hand, if we raise the reference value, we will minimize the number of false alarms, but unfortunately, we stand to lose some of our targets.

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False alarm rate is defined to be the quotient of all false alarms referenced to some parameter value of all records of data considered divided by the number of pings. The probability of detection is defined to be the quotient of all detected targets in the data base divided by all the targets of the data base. With respect to each reference value, we can compute a probability of detection and a false alarm rate. By varying the reference value over a range of values, we can obtain a table of probabilities versus false alarm rates. From them we can obtain a graph in which the probability of detection varies from 0 to 1 and the false alarm rate varies from zero to the average number of non-targets per ping in the data base.

A parameter in this context is that measure of a cluster which is used as a criterion for separating targets from non-targets. The utility of a parameter as a criterion for separating targets from non-targets is given by the graphing of false alarm rate versus probability of detection. One parameter is defined to be better than another parameter at a specified false alarm rate value if the probability of detection at that point is greater than the other. Let FARATE be the false alarm rate and PROB A be the probability of detection of parameter A. For example, suppose one superimposes the graphs of an analysis of parameter A over parameter B and at FARATE = 0.10, PROB A = .68 and PROB B = .52. Then one would say that at FARATE = 0.10, parameter A is better than parameter B.

The purpose of PARAMETER ANALYSIS can be more precisely stated. The purpose is to find better parameters than confidence level, better being defined as above.

Another objective of this analysis is to explore the possibility of using parameters to distinguish between different kinds of targets. Clusters are divided into targets and non-targets. Targets are further dividable into

submarines, destroyers, and so on. A submarine target may show different sides with respect to the detecting sonar system. It may show its bow, stern, beam and so forth. This is defined to be an aspect. An aspect in this context is sub-classification of a target cluster. A secondary objective of this analysis is to establish the research background for discovering criteria for separating and classifying target aspects.

The parameters used in this analysis are not necessarily the best parameters to use for thresholding clusters nor are they the only parameters which could be used. They were chosen by the staff at Stanford Electronics Laboratory in their research analysis upon the LORAD-ADELINE data. Stanford's research on this is explained in SEL Report 65-078. These parameters are nineteen in number and by name are (1) average amplitude, (2) cluster density, (3) confidence level, (4) doppler amplitude sum, (5) leading range slope, (6) maximum bearing sum, (7) maximum correlation amplitude, (8) maximum range sum, (9) normalized maximum amplitude deviation, (10) normalized number of elements, (11) normalized sequential difference, (12) number of elements, (13) peak adjacent difference sum, (14) range bearing sum difference, (15) range standard deviation, (16) second maximum bearing sum, (17) second maximum range sum, (18) standard deviation density, and (19) trailing range slope.

THE INPUT DATA BASE

The input data base to parameter analysis is produced by the systems PINGASPDEF and RWRITETAPE. The input data base consists of a number of records terminated by an end of file marker. Each record has a maximum length of 11401 octal words. The first word of each record is the ping number of the record. The next 1400 words represent the area in which the CC table resides, which may or may not be completely filled; usually it

isn't. The last 10000 cells is the area for the AXTDS table. Practically speaking, it is never full.

The CC (cluster characteristics) table is a 400 item horizontal three-word per item table. The first word of the item contains the fields TRUERANGE, NR2RDOT, NR1RDOT, and ASPECT. TRUERANGE is a 15-bit field which contains the mean range of the cluster, NR1RDOT and NR2RDOT are each 3-bit fields containing the most likely and second most likely doppler codes of the cluster respectively. ASPECT is a 6-bit field which contains the target classification information, zero for a non-target, otherwise for a target. The second word of the CC item contains fields LOITEMNR and HIITEMNR, which are the index value limits of the cluster words contained in AXTDS. LOITEMNR is a 15-bit field containing the lowest index value of the cluster in AXTDS. HIITEMNR is a 15-bit field which has the highest index value of the cluster. The third word of the CC item has the two 15-bit fields of MAXCORRAMP and CONFLEVEL. MAXCORRAMP stands for the maximum correlation amplitude of the cluster. MAXCORRAMP is the highest AMP of the elements of a cluster. CONFLEVEL stands for confidence level, which is the sum of the AMPs of a cluster.

The AXTDS (auxiliary temporary data storage) table is a 10,000 item horizontal one-word per item table. This table contains the actual cluster words to which the CC table is referred. The item contains the fields P, AMP, RR, BEAMNR, AUXIND, and RANGE. P is a 1-bit field not significant in this analysis. AMP is a 5-bit field containing the amplitude of the word. RR is a 3-bit field indicating a doppler range rate code. BEAMNR is a 4-bit field signifying the direction from which the information came; AUXIND is a 2-bit field not used in this analysis. RANGE is a 15-bit field whose function is self-explanatory.

OUTPUT

Output of all systems is on a high speed printer. The output is in the following format: Two sets of tables are printed out, each of which has the following format: A target classification header followed by a column header followed by eight columns of figures. The first column is the parameter value of each line. The second column is the false alarm rate; the remaining six columns are the probabilities of detection. There are twelve aspects in all: (1) submarine's beam aspect, (2) submarine's bow aspect, (3) submarine's quartering aspect, (4) destroyer's bow aspect, (5) destroyer's stern aspect, (6) destroyer's beam aspect, (7) all targets, (8) all submarines, (9) all destroyers, (10) all non-echo repeaters, (11) echo repeaters, and (12) submarine's surfaced aspect.

THEORY OF COMPUTATION

The tables used in every system are THRSH, MISTY, TOTAL, PARAM, AXTDS, and CC. Table THRSH is a 1-word per item table whose item length varies from system to system. Its function is to record the number of clusters processed whose parameter values equal or exceed the reference value, which is given by the item number. Table MISTY is a 6-word per item 12-field table whose item length varies from system to system. The 12 fields correspond to the 12 target classifications. Its function is to record the number of target clusters processed whose parameter values equal or exceed the reference value which is given by the item number. TOTAL is a 6-word 1-item 12-field table whose 12 fields correspond to the 12 target aspects. Table PARAM is a 400-item table whose items correspond to those of table CC. The items of table PARAM contain the parameter values of each cluster to which they refer.

False alarm rate and probability of detection are computed in the following manner: the number of false alarms, FAS, is given by:

FAS = THRSH(X) - MISTY(X, ALL TARGETS)

The false alarm rate, FARATE, and probability of detection, PROB, are given by:

FARATE = FAS/TOPINGS

PROB = MISTY(X, type)/TOTAL(type)

where X is the reference value which is varied throughout the range of values taken on by MISTY and TOPINGS is the total number of records.

The procedures used in every system are an EXECUTIVE of some sort, UPDATTOTAL, UPDATMISTY, PRINTMISTY and a routine which computes the parameter values. This last varies from system to system.

The EXECUTIVE procedure falls into two classes: the single parameter executive subroutine as exemplified by the executive of the MAXCORRAMP system and the double parameter executive subroutine as exemplified by the executive of the BEARING system. the EXECUTIVE subroutine is just that. It calls on other subroutines, reads in the data, processes it, updates the tables, and when all the pings have been read in, it rewinds the data tape and calls on PRINTMISTY to print out the appropriate information.

The procedure UPDATTOTAL searches through the cluster list for target aspects, and when it finds one, it increments the appropriate target field.

The procedure UPDATMISTY indexes through table MISTY item by item and searches for a parameter value equal to or surpassing the item number of MISTY in table PARAM. When such an item is found, the PINDEX item in table THRSH is incremented by one, and if the parameter item is a target, the PINDEX item and appropriate aspect in MISTY is incremented by one.

Procedure PRINTMISTY computes the values of the table columns and outputs them to the high speed printer.

THE PARAMETER SYSTEMS

There are altogether seventeen parameter systems. They are: PARAMP2, MAXCORRAMP, CONFLEVEL, BEARING, RANGESUMS, AVERAGEAMP, RNGBEARDIF, ELEMENTS, NORMSEQDIF, CLUSTDENS, LEADSLOPE, TRALSLOPE, STDENSITY, NORMNUMEL, PEAKDIFFER, DOPPLER, and RANGESIG.

The following parameters with their definitions were taken from Stanford Electronics Laboratories, Report 65-078 entitled Studies in Adaptive Processing of Underwater Sound Signals, pp 6-11.

PARAMP2

This system is an analysis of a parameter called normalized maximum amplitude deviation, which is defined as follows:

$$P_2 = \sum_{i=1}^{N} \frac{X_{MAX} - X_i}{N}$$

where X_{MAX} represents the maximum correlation amplitude of a cluster and X_i represents the amplitude of the i-th element of a cluster and N represents the number of elements of a cluster. The subroutine which computes this parameter is FINDP2. FINDP2 computes NMAXAMPDEV in 16ths of incremental values and stores the results in the table PARAM. The range of MISTY and THRSH in this parameter is 160.

MAXCORRAMP

The PARAM table is filled by procedure FINDP1. This system analyzes the maximum correlation amplitude parameter, which is defined within the data base itself. Maximum correlation amplitude is the highest amplitude of the words of a cluster. The range of this parameter is 32 values.

CONFLEVEL

The PARAM table is filled by procedure FINDCONFLV. This system analyzes

the confidence level parameter. Confidence level is defined within the data base and is the sum of the amplitudes of all the elements of a cluster. The range of this parameter is 400 values.

BEARING

This system performs a double analysis. Two parameters are found; the maximum bearing sum and the second maximum bearing sum. Maximum bearing sum is the maximum of the amplitude sums over range of all elements in one bearing increment. Second maximum bearing sum is the second highest amplitude sum. The subroutine which finds these parameters is FINDBEARSM. FINDBEARSM indexes through the cluster list, pulls out the appropriate cluster information, fills a bearing table, finds the maximum and second maximum bearing sum and stores this information in table PARAM. The range of these parameters is 201 items.

RANGESUMS

This is another double parameter analysis. The two parameters are the maximum range sum and the second maximum range sum. The maximum range sum is the maximum of the amplitude sums over bearing of all elements in one range increment. The second maximum range sum is the second highest amplitude sum. The subroutine which finds these parameters is FINDMAXRNG. FINDMAXRNG indexes through the cluster list, fills the table RANGE for each cluster, finds the maximum range sum and the second maximum range sum, and stores the information in table PARAM. The range of these parameters is 200 items.

AVERAGEAMP

The average amplitude parameter of a cluster, P_3, is computed as follows:

$$P_3 = \frac{1}{N} \sum_{i=1}^{N} X_i$$

where N is the number of elements and X_i is the amplitude of each element. The procedure FINDP3 computes this parameter in tenths of integer values. The range of this parameter is 311 items.

RNGBEARDIF

The parameter range-bearing sum difference, P_{10}, is computed as follows:

$$P_{1C} = 100 + (RS)_{MAX} - (BS)_{MAX}$$

where $(RS)_{MAX}$ represents the maximum range sum of a cluster and $(BS)_{MAX}$ represents the maximum bearing sum. Procedure RBSUMDIFF which computes this calls on FINDMAXRNG and FINDBEARSM. The range of this parameter is 201 items.

ELEMENTS

This system is an analysis of the number of elements parameter. The subroutine which fills table PARAM is NELEMENTS. The range of this parameter is 51 values.

NORMSEQDIF

This system is an analysis of the normalized sequential difference parameter. The normalized sequential difference parameter is computed as follows:

$$P_8 = \frac{1}{N} \sum_{i=1}^{N} \left| X_{i+1} - X_i \right|$$

where X_i represents the amplitude of the i-th element. The subroutine NEQDIFF computes the parameter values in 25ths of integer values. The range of this parameter is 201 values.

CLUSTDENS

This system is an analysis of the cluster density parameter. It is computed as follows:

$$P_{14} = \frac{\sum_{i=1}^{N} X_i}{N_B\, N_R}$$

where N_B is the number of bearing increments spanned by the cluster and N_R is the number of range increments spanned by the cluster. The parameter is actually computed by using CONFLEVEL as the numerator. The subroutine CLDENSITY computes the parameter values to tenths of integers with a range of 301 values.

LEADSLOPE

The leading range slope parameter is computed from the following equation:

$$P_{11} = \frac{(RS)_{MAX} - (RS)_1}{R_c - R_1}$$

where $(RS)_1$ represents the first range sum of the cluster, $(RS)_{MAX}$, the maximum range sum of the cluster, R_1 the first range and R_c the range at which $(RS)_{MAX}$ occurs. If $R_c = R_1$, the value of P_{11} is defined to be zero. The subroutine LRSLOPE computes these parameter values in half-integer values with a range of 161 values.

TRALSLOPE

TRALSLOPE is similar to the LEADSLOPE system. The trailing range slope parameter is given by:

$$P_{12} = \frac{(RS)_{MAX} - (RS)_2}{R_2 - R_c}$$

where $(RS)_2$ represents the last range sum of a parameter and R_2 represents the last range. TRSLOPE computes this parameter in a manner similar to LRSLOPE. P_{12} is defined to be zero when $P_2 = P_c$.

STDENSITY

The standard deviation density parameter is given by:

$$P_{16} = \frac{\sum_{i=1}^{N} X_i}{\sigma_R \, \sigma_B}$$

where here again the numerator is the confidence level of the cluster; σ_R is the range standard deviation, and σ_B is the bearing standard deviation which are computed as follows:

$$\sigma_R = \frac{1}{\sum_{i=1}^{N} X_i} \left\{ \sum_{i=1}^{N} X_i \, r_i^2 - \frac{\left(\sum_{i=1}^{N} X_i \, r_i\right)^2}{\sum_{i=1}^{N} X_i} \right\}$$

where X_i is the amplitude of the i-th element of the cluster and r_i is the range of the 8-th element.

$$\sigma_B = \frac{1}{\sum_{i=1}^{N} X_i} \left\{ \sum_{i=1}^{N} X_i \, b_i^2 - \frac{\left(\sum_{i=1}^{N} X_i \, b_i\right)^2}{\sum_{i=1}^{N} X_i} \right\}$$

where b_i is the bearing of the i-th element of a cluster. These computations were somewhat simplified by using the relation that CONFLEVEL $= \sum_{i=1}^{N} X_i$. Procedure STDENSITY computes this parameter by first calling on two daughter subroutines RANGSTNDEV to compute σ_R and BEARSTNDEV to compute σ_B. σ_R and σ_B are both computed in 100ths of integer values while P_{16} is computed to the nearest whole number. The range of parameter analysis is 401 values.

NORMNUMEL

This system analyzes the normalized number of elements parameter. It is given as follows:

$$P_{17} = \frac{N}{N_B \, N_R}$$

The procedure NORMALNUM computes this parameter to the nearest half-integer value over a range of 61 values.

PEAKDIFFER

The peak adjacent difference sum parameter is given by:

$$P_{13} = A + B$$

where A and B represent the differences between the maximum range sum and the adjacent range sums on both sides. The PEAKDIFFER parameter is computed by procedure PKADJDIFSM in integer values over a range of 151 values.

DOPPLER

The doppler amplitude sum parameter is given by:

$$P_{18} = \frac{\sum_{i=1}^{N} X_i \bar{D}}{N}$$

where $\bar{D}$ = +1 if doppler associated with amplitude X_i is the model doppler of the cluster and -1 otherwise. Procedure DOPPLERAMP computes doppler to the nearest half-integer over a range of 401 values.

RANGESIG

The range standard deviation parameter is computed by procedure RANGSTNDEV as explained and defined in STDENSITY above. The parameter is computed for each cluster to the nearest 100th of an integer over a range of 301 values.

SYSTEM USE

Each system is on mag tape and to be used must be called into the computer with a LOD40 card allocated to the base address of 01000. PRINT and FLOP must be called in from the MONITOR library to run with this program. PRINT is allocated to 50000 and FLOP to 20000. To use the system, mount the program tape on M2, the data tape on M3, LOAD the program desired, PRINT, and FLOP and transfer to 01000.

Parameter Systems Analysis Programs are on tape 210 and FT-56. FT-56 is to be considered the permanent backup tape to be used only to generate user tapes. Tape 210 is to be the user tape. There are two outputs for each program, an output 46 and an output 40. 46's are on even files and 40's are on odd files. The contents of tapes 210 and FT-56 are listed in Appendix 1. Appendix 2 lists the parameters alphabetically with their corresponding systems.

Except for the following appendices and flow diagrams of the various subroutines of the analysis systems, these remarks conclude the documentation of these programs. Research using the parameters herein described is currently in progress. It is hoped that further investigation of these parameters and perhaps others, either simply or in combination, will yield a better cluster thresholding criteria than the confidence level parameter now is use.

APPENDIX 1

File Number		Outputs		System	Data Compiled
0	1	46	40	PARAMP2	1 Dec 65
2	3	46	40	ASPECTDEF	4 Oct 65
4	5	46	40	MAXCORRAMP	4 Jan 66
6	7	46	40	CONFLEVEL	4 Jan 66
10	11	46	40	BEARING	20 Jan 66
12	13	46	40	RANGESUMS	7 Jan 66
14	15	46	40	AVERAGEAMP	7 Jan 66
16	17	46	40	RNGBEARDIF	31 Jan 66
20	21	46	40	ELEMENTS	21 Jan 66
22	23	46	40	NORMSEQDIF	21 Jan 66
24	25	46	40	CLUSTDENS	28 Jan 66
26	27	46	40	LEADSLOPE	23 Feb 66
30	31	46	40	TRALSLOPE	23 Feb 66
32	33	46	40	STDENSITY	11 Feb 66
34	35	46	40	NORMNUMEL	23 Feb 66
36	37	46	40	PEAKDIFFER	24 Feb 66
40	41	46	40	DOPPLER	7 Feb 66
42	43	46	40	RWRITETAPE	26 Nov 65
44	45	46	40	RANGESIG	25 Feb 66

APPENDIX 2

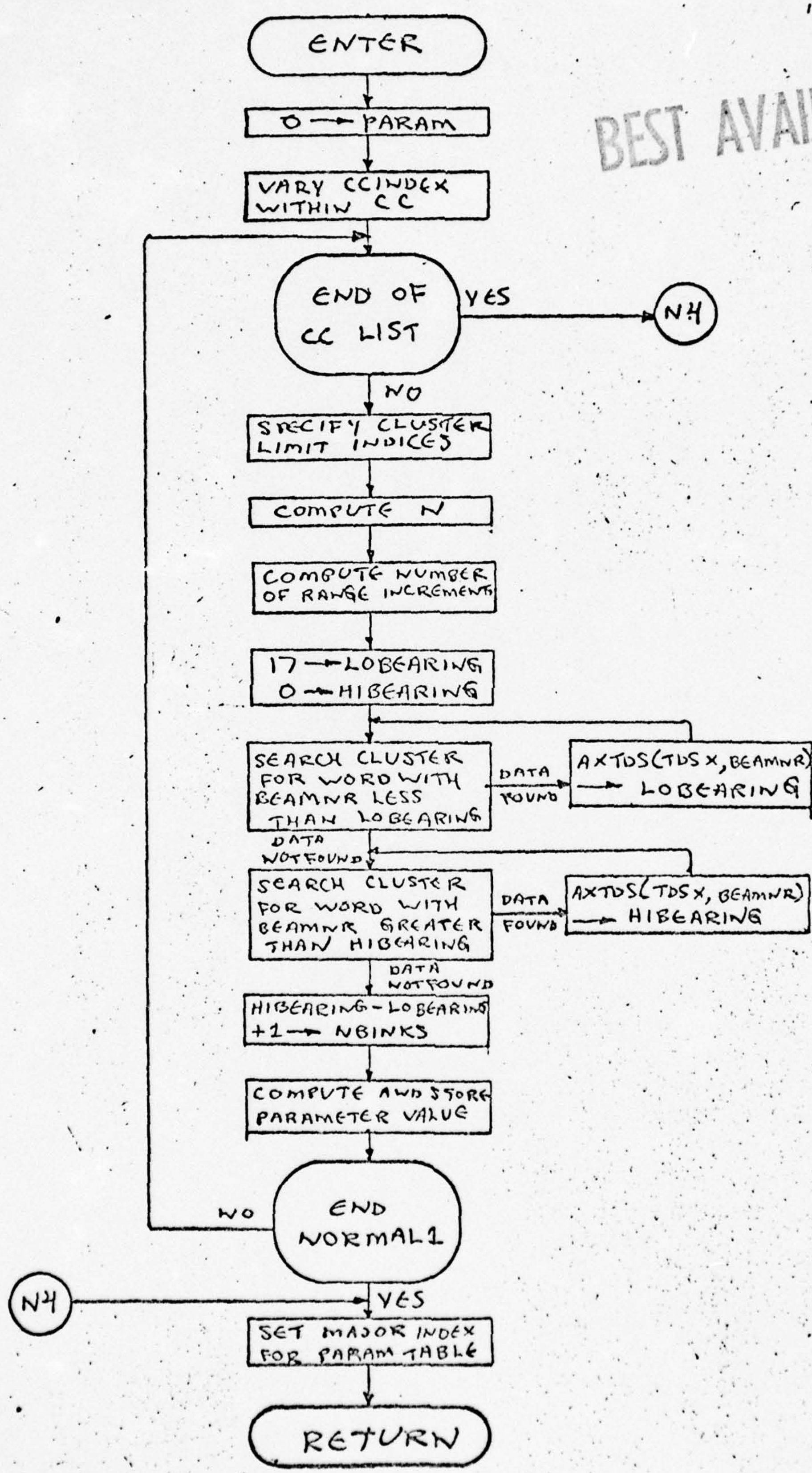
Parameter Name	System Name
Average Amplitude	AVERAGEAMP
Cluster Density	CLUSTDENS
Confidence Level	CONFLEVEL
Doppler Amplitude Sum	DOPPLER
Leading Range Slope	LEADSLOPE
Maximum Bearing Sum	BEARING
Maximum Correlation Amplitude	MAXCORRAMP
Maximum Range Sum	RANGESUMS
Normalized Maximum Amplitude Deviation	PARAMP2
Normalized Number of Elements	NORMNUMEL
Normalized Sequential Difference	NORMSEQDIF
Number of Elements	ELEMENTS
Peak Adjacent Difference Sum	PEAKDIFFER
Range Bearing Sum Difference	RNGBEARDIF
Range Standard Deviation	RANGESIG
Second Maximum Bearing Sum	BEARING
Second Maximum Range Sum	RANGESUMS
Standard Deviation Density	STDENSITY
Trailing Range Slope	TRALSLOPE

REFERENCES

Studies in Adaptive Processing of Underwater Sound Signals, Qarterly Progress Report Number 4, Rept. SU-SEL-65-078, Stanford Electronics Laboratory, Stanford, California, August 1965 (Report CONFIDENTIAL, title unclassified) prepared by B. Widrow and others.

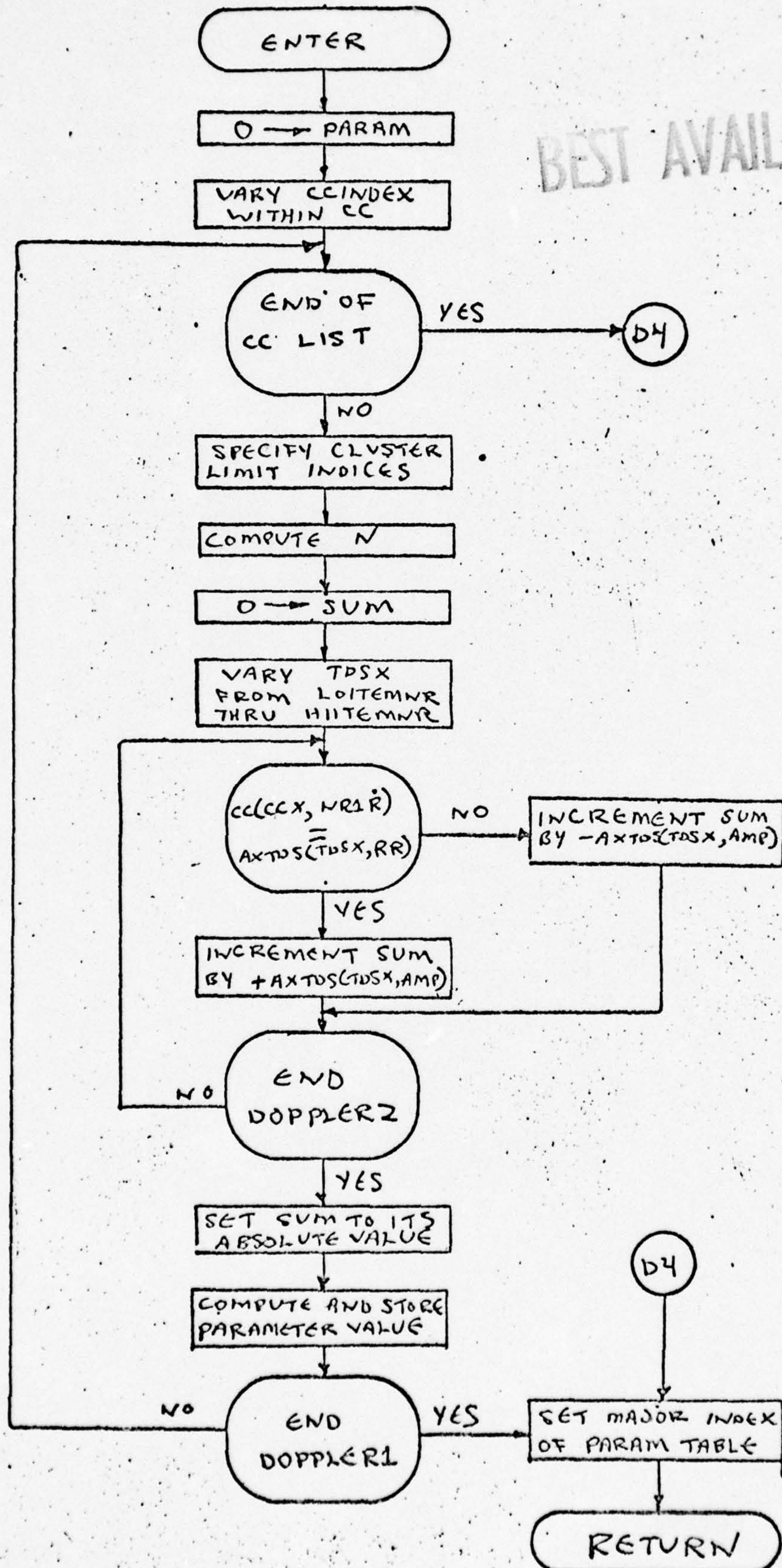
NORMALIZED NUMBER OF ELEMENTS PARAMETER SYSTEM

NORMALNUM S/R



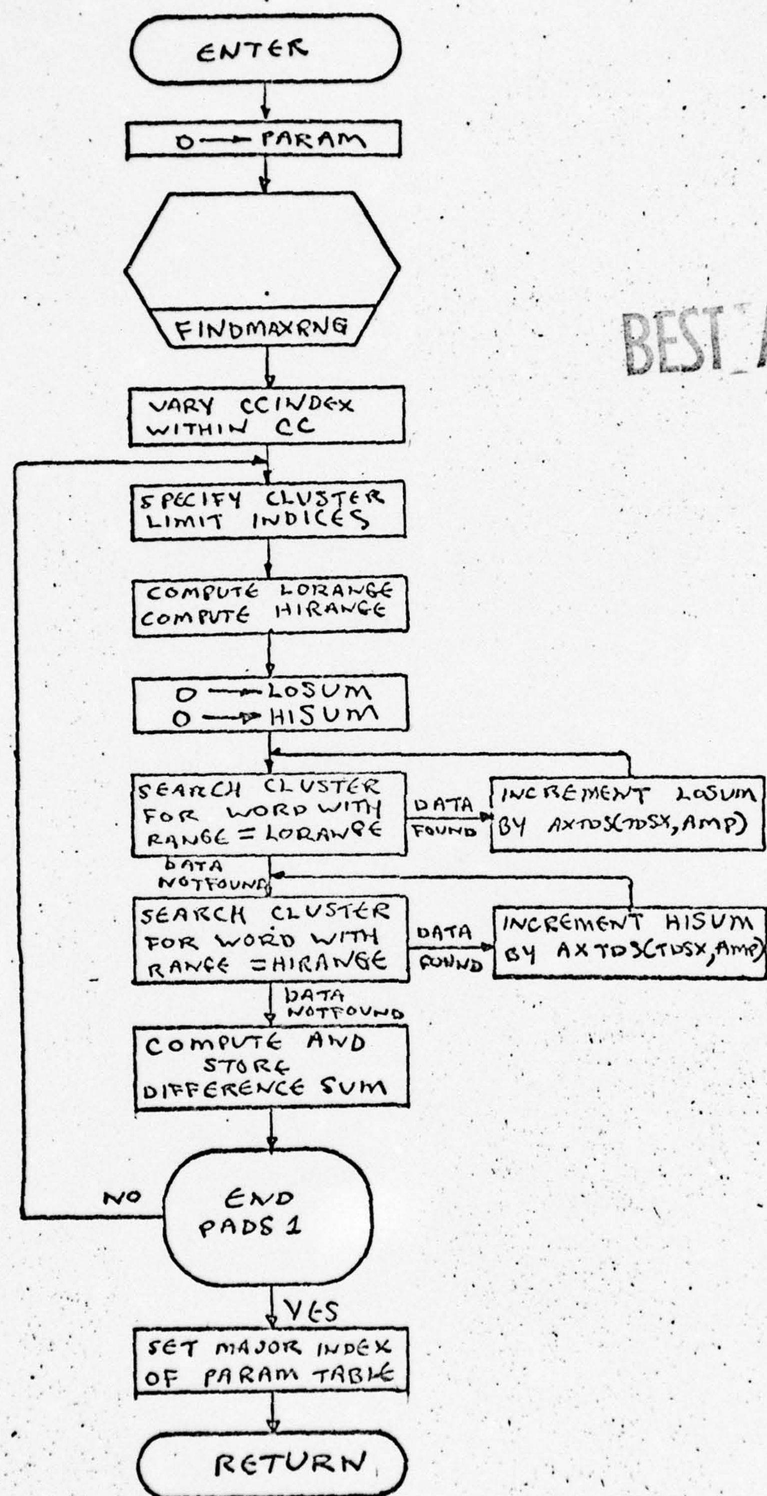
DOPPLER AMPLITUDE SUM PARAMETER SYSTEM

DOPPLERAMP S/R



PEAK ADJACENT DIFFERENCE SUM PARAMETER SYSTEM

PKADJDIFSM S/R



STANDARD DEVIATION DENSITY PARAMETER SYSTEM

STDENSITY S/R

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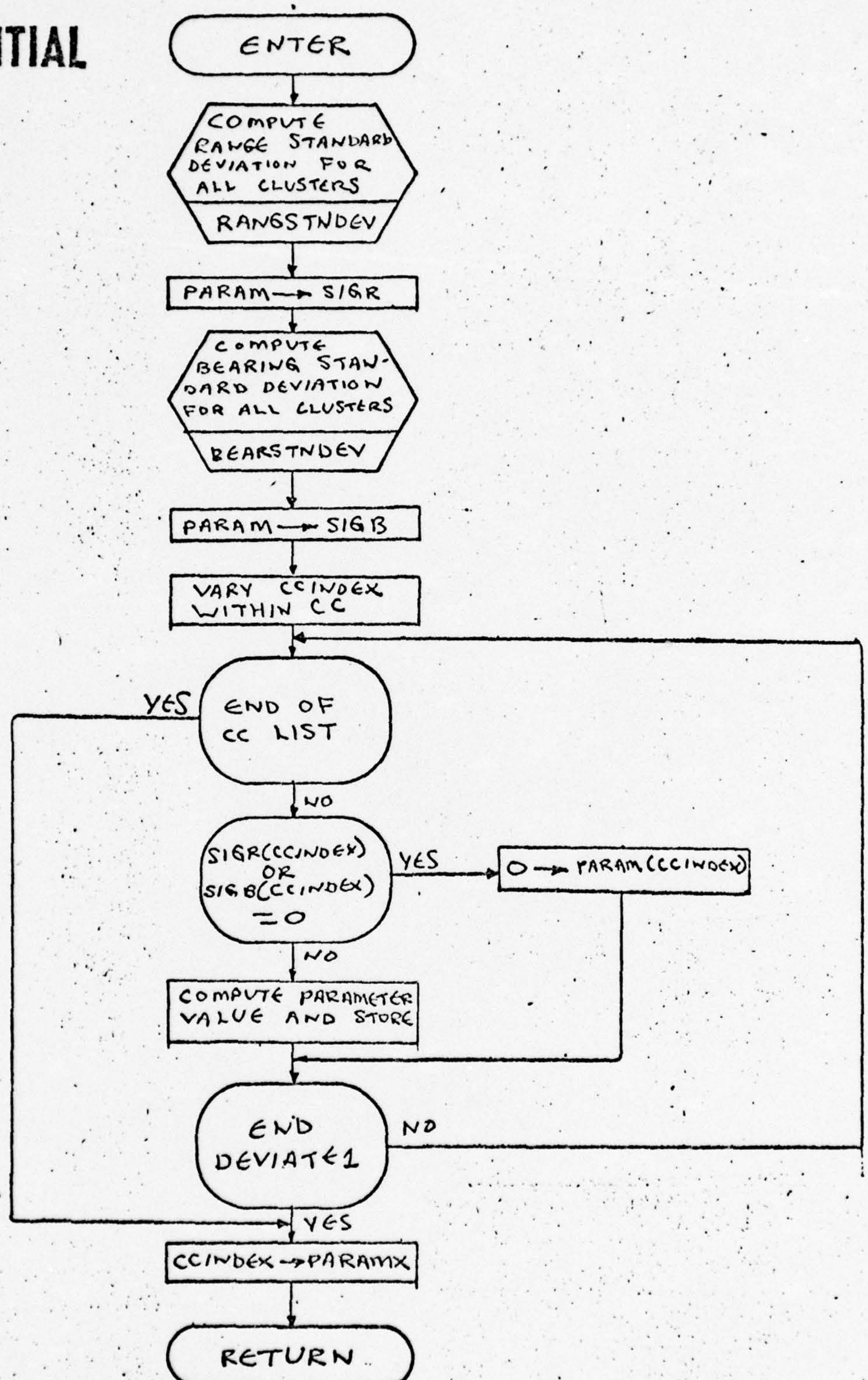

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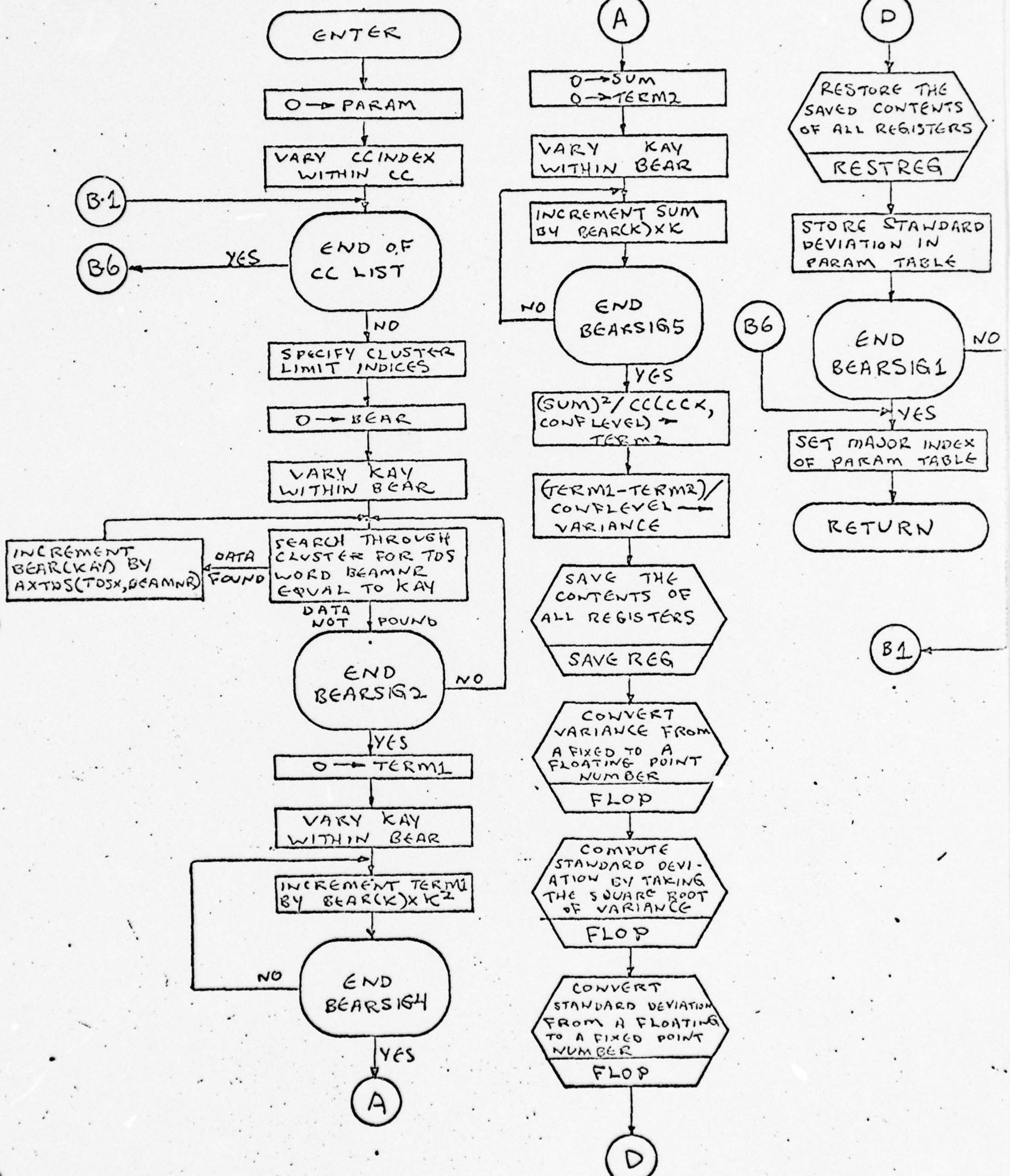
STANDARD DEVIATION DENSITY PARAMETER SYSTEM

BEARSTNDEV S/R



. CLUSTER DENSITY PARAMETER SYSTEM

. CLDENSITY S/R

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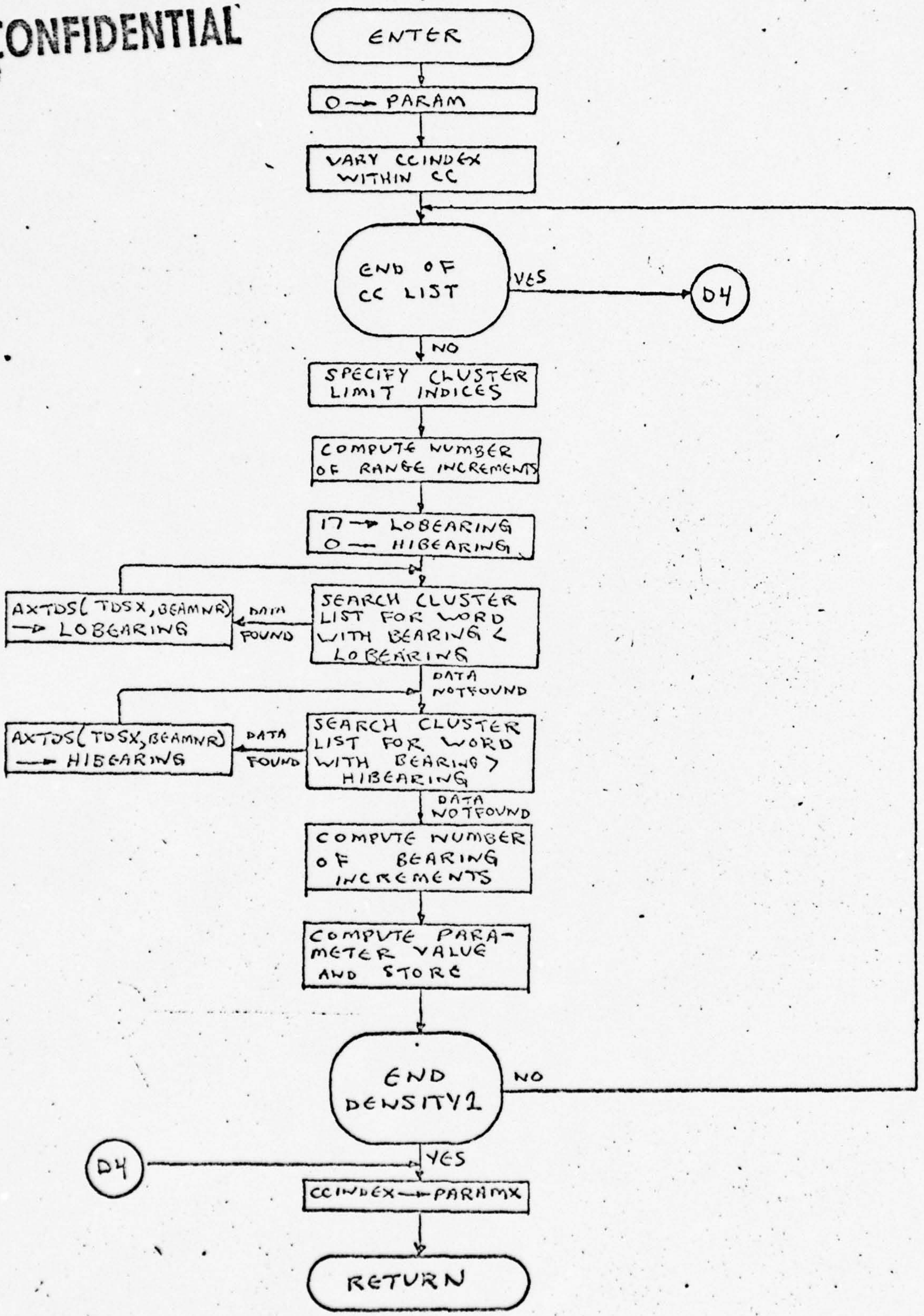

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TRAILING RANGE SLOPE PARAMETER SYSTEM

TRSLOPE S/R

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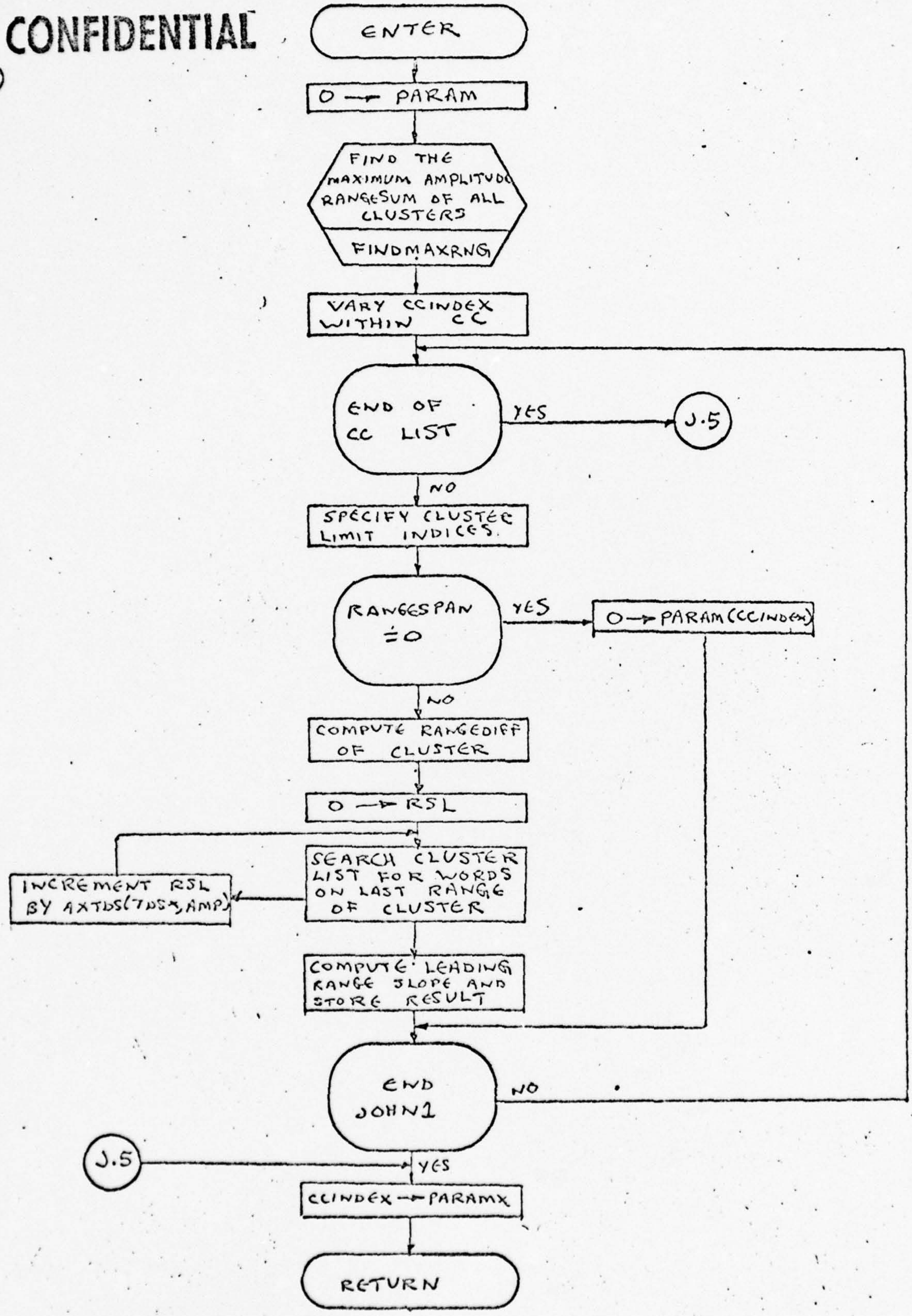

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LEADING RANGE SLOPE PARAMETER SYSTEM

LRSLOPE S/R

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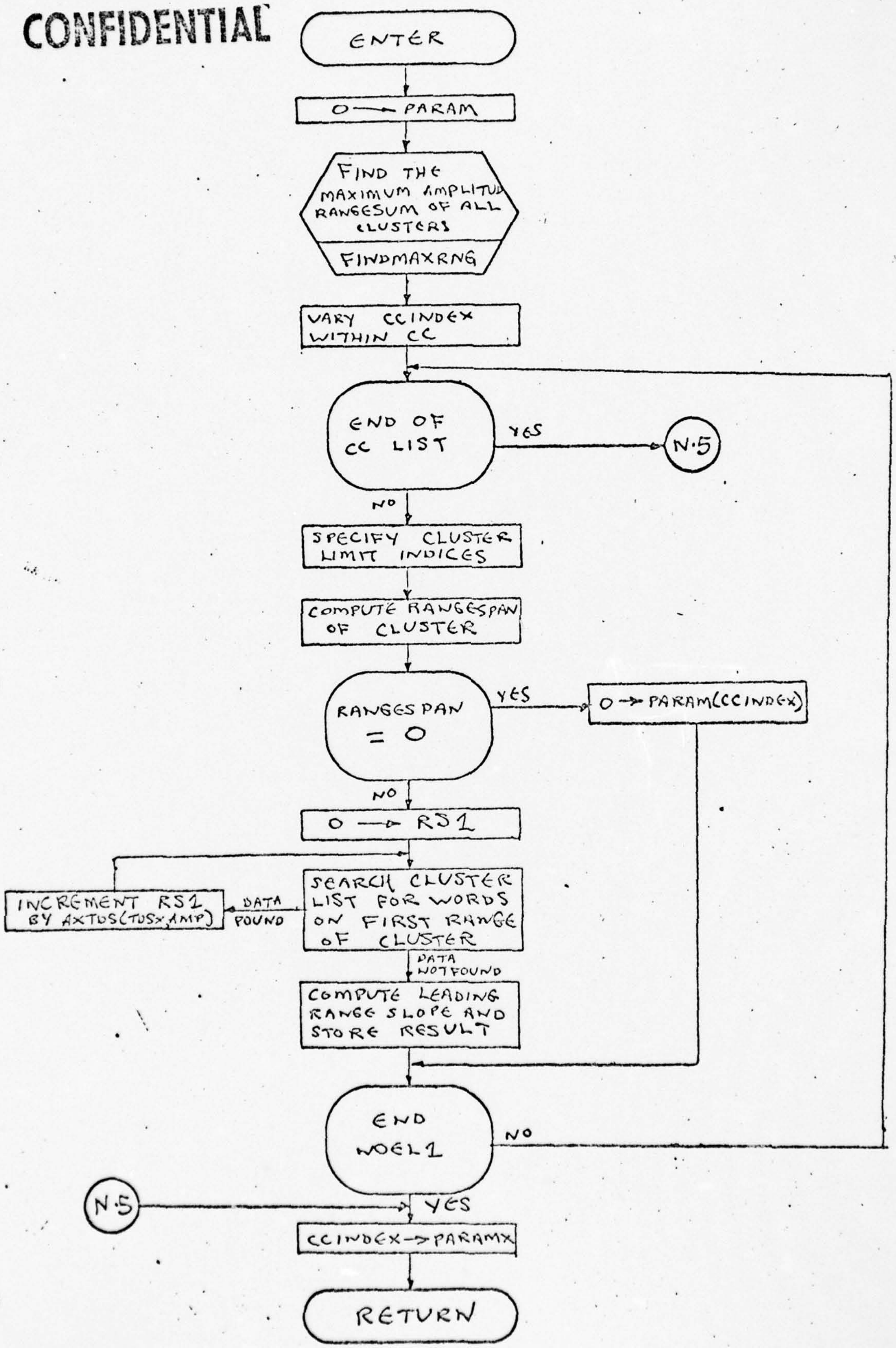

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SYSTEM ANALYSIS OF THE NUMBER OF ELEMENTS PARAMETER
NELEMENTS S/R

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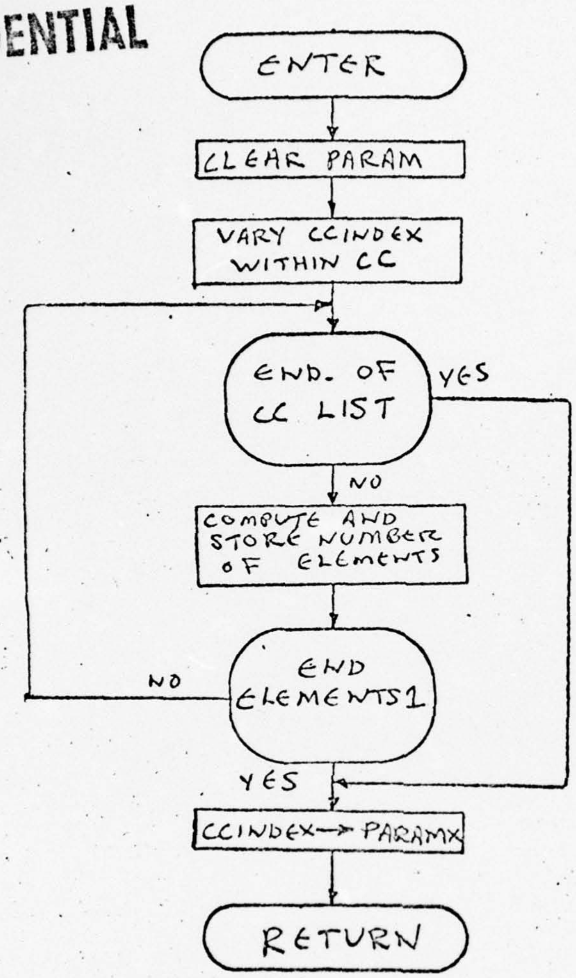

SYSTEM ANALYSIS OF THE RANGE STANDARD DEVIATION PARAMETER

RANGSTNDEV S/R

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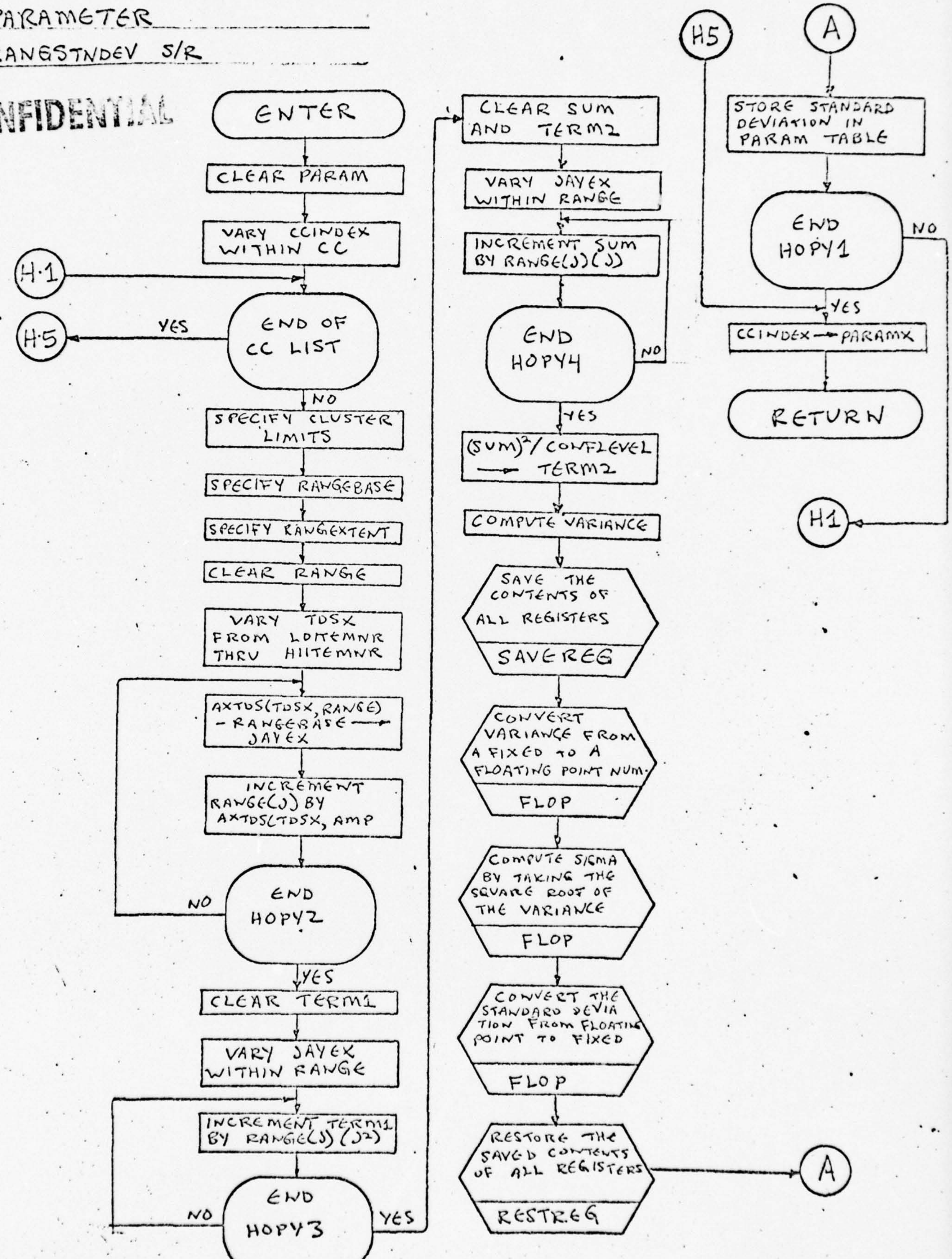

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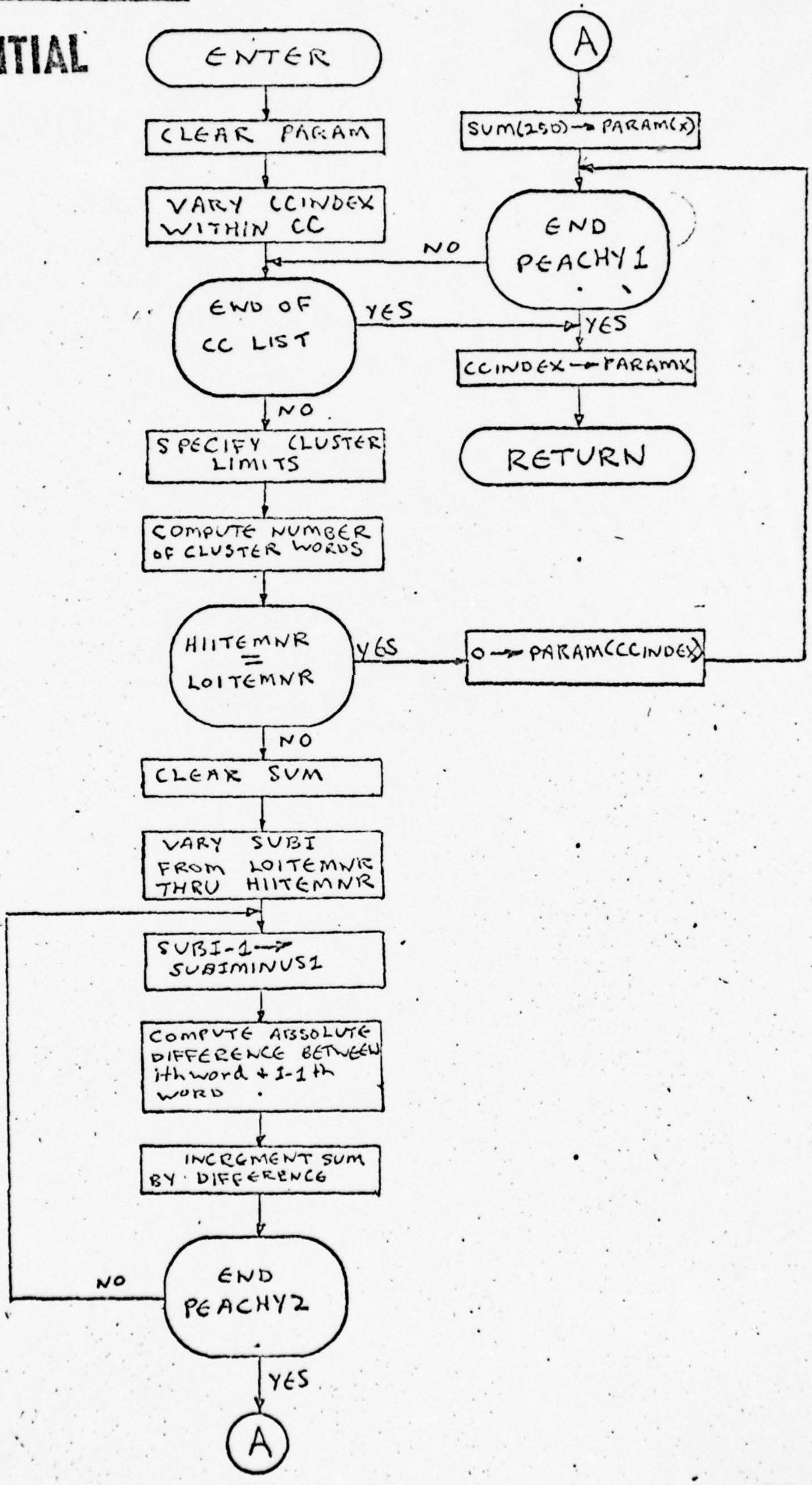
SYSTEM ANALYSIS OF NORMALIZED SEQUENTIAL DIFFERENCE PARAMETER
NSEQDIFF S/R



SYSTEM ANALYSIS OF RANGE-BEARING SUM DIFFERENCE PARAMETER

RBSUMDIFF: S/R

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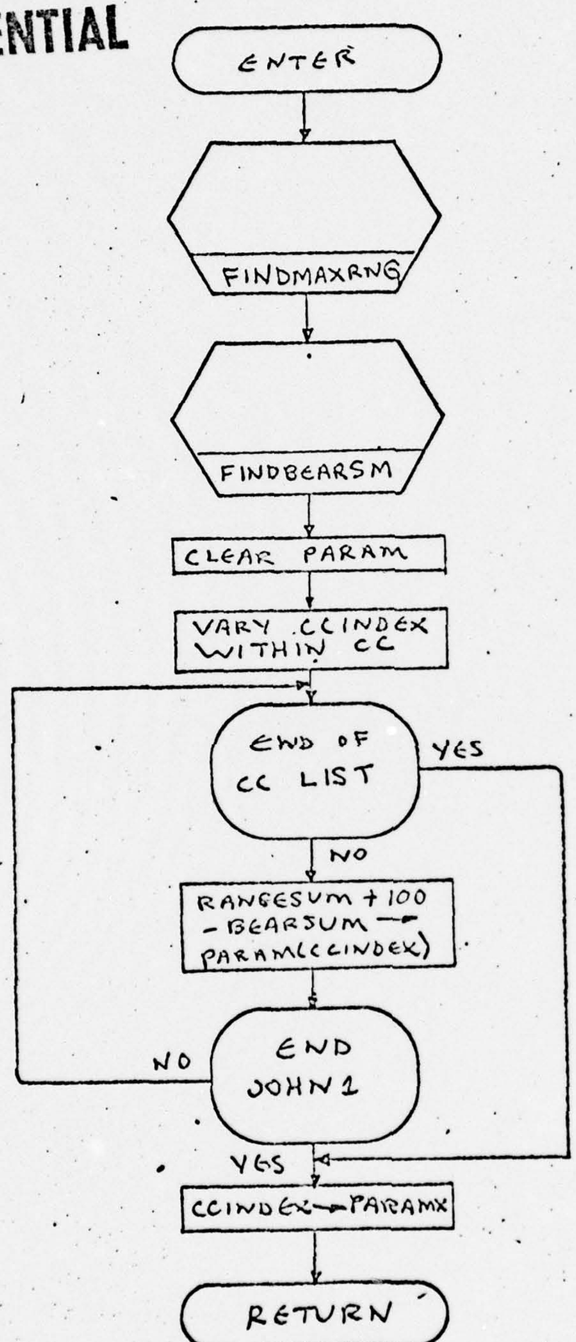

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MAXIMUM AND SECOND MAXIMUM BEARING SUM PARAM. SYSTEM EXECUTIVE S/R

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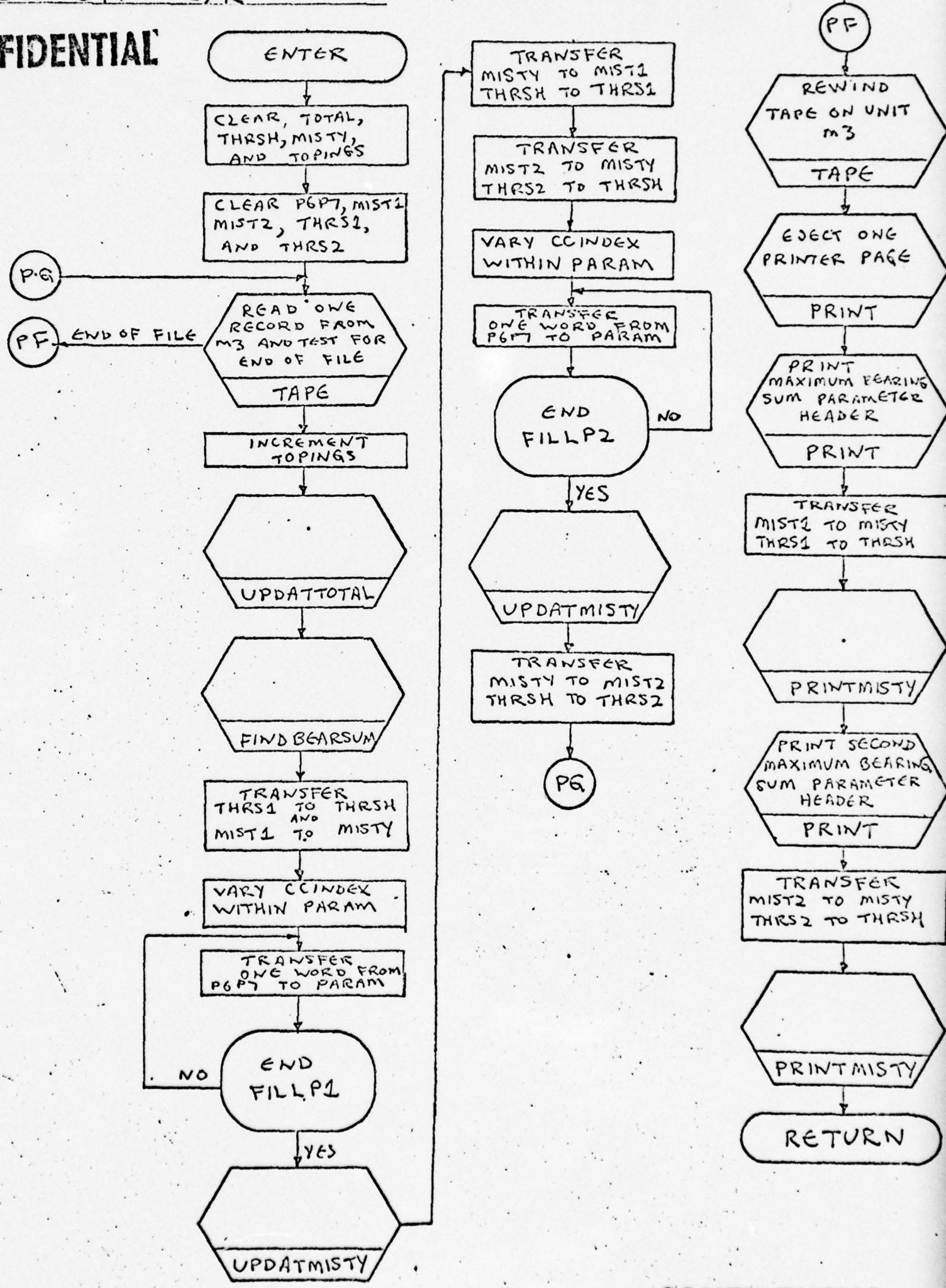

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FINDBEARSM

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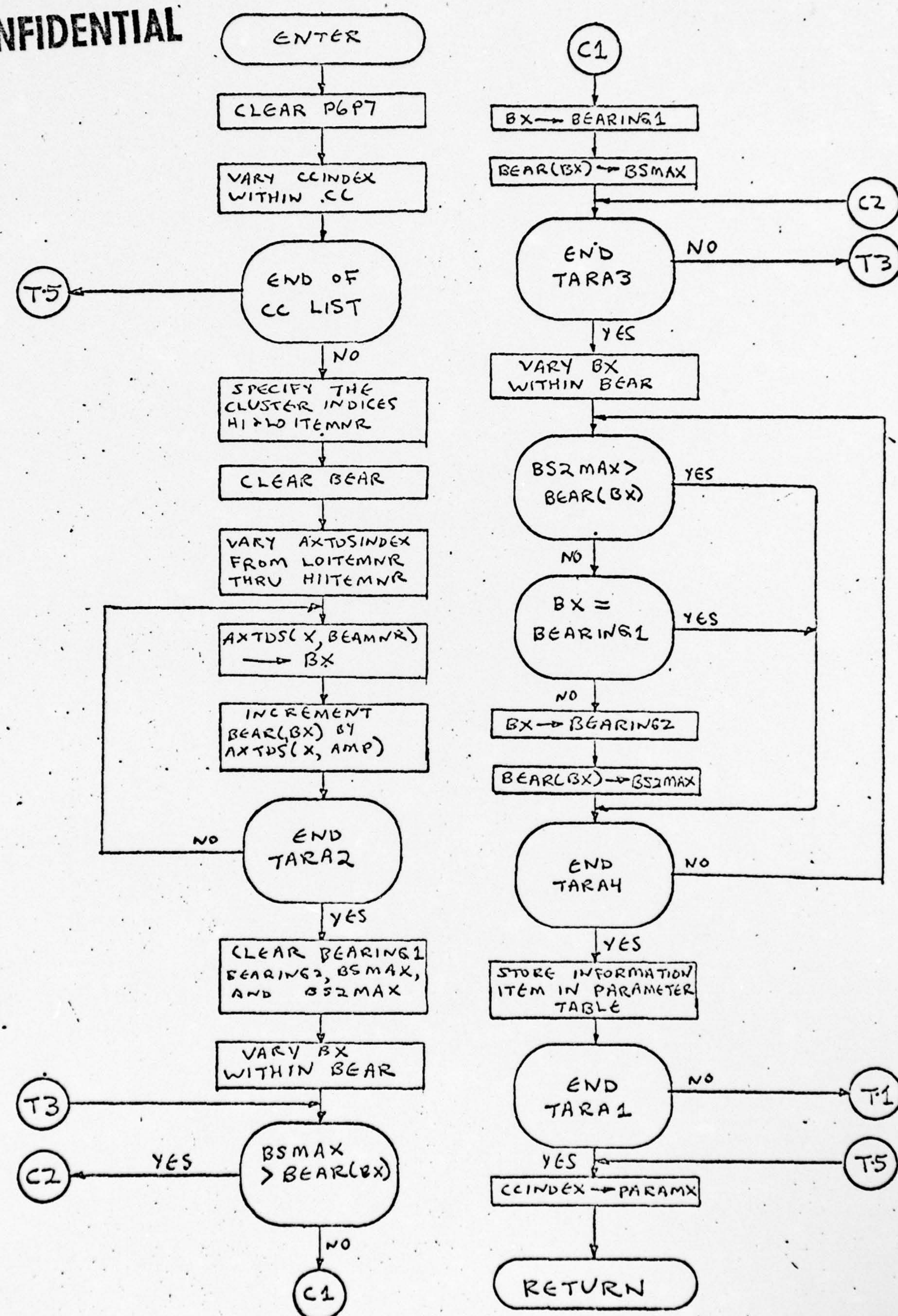
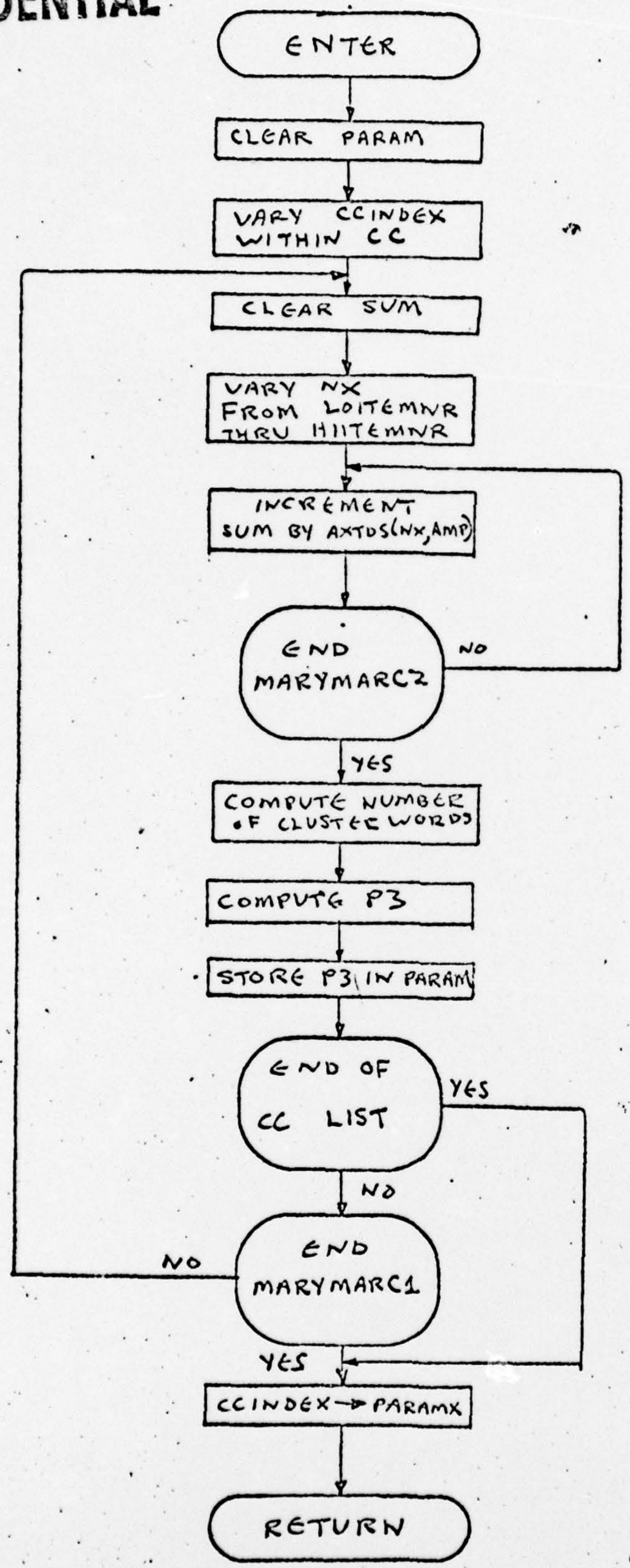


CONFIDENTIAL

FINDP3 (SYSTEM AVERAGEAMP)

CONFIDENTIAL



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FINDMAXRNG

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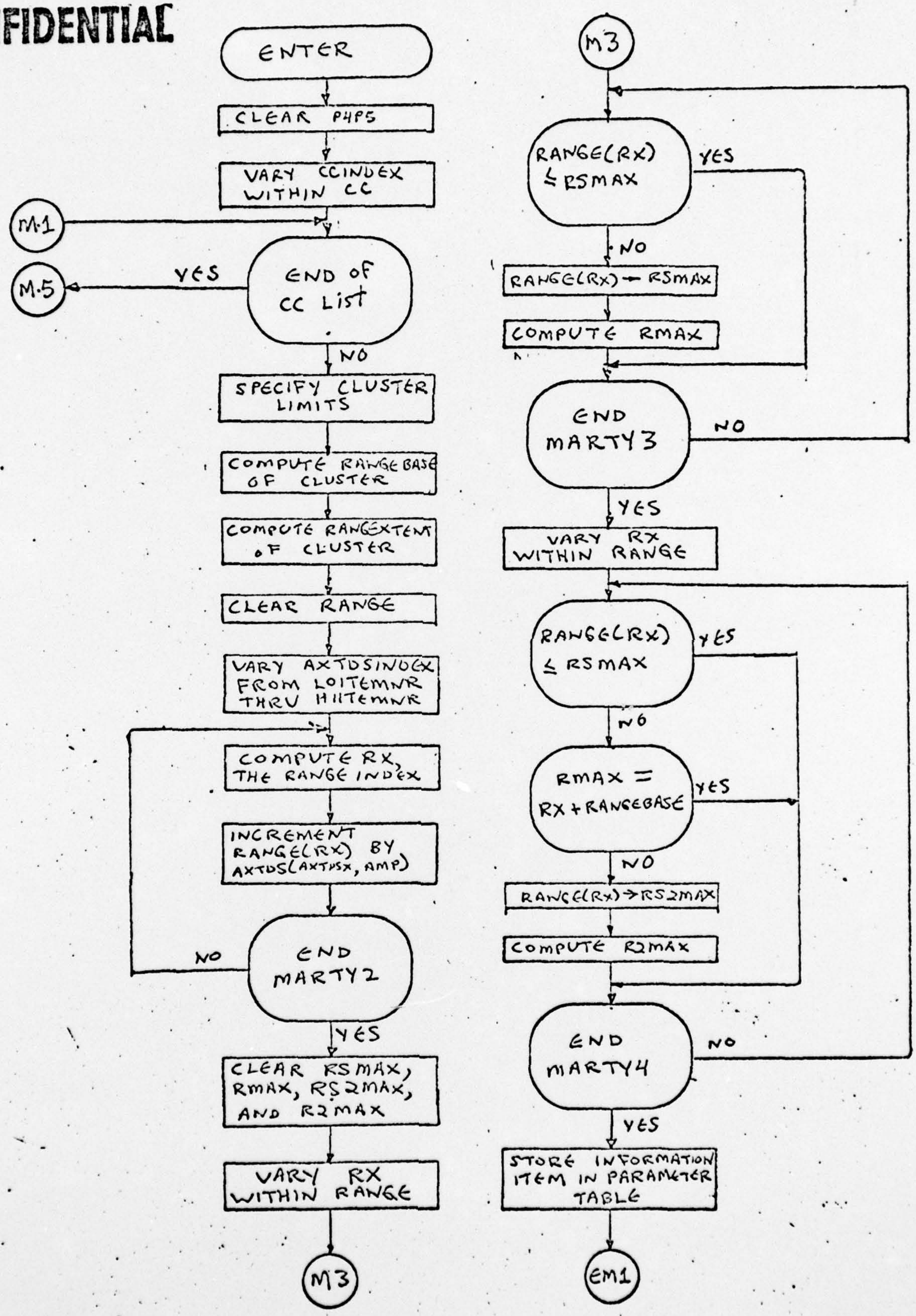

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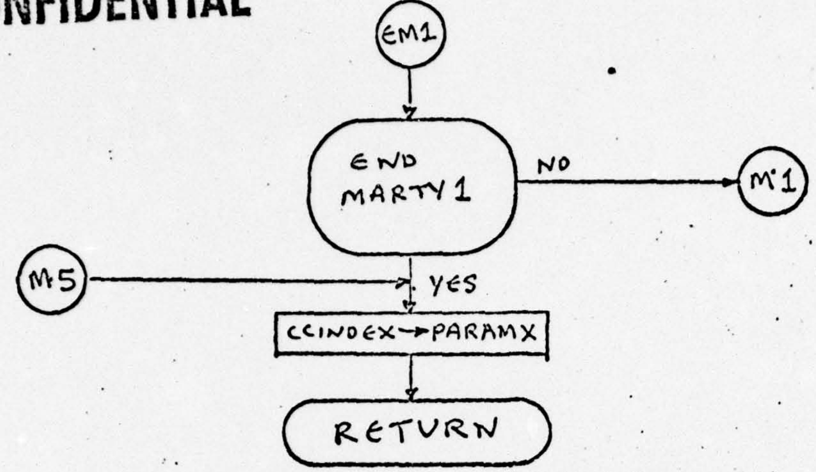

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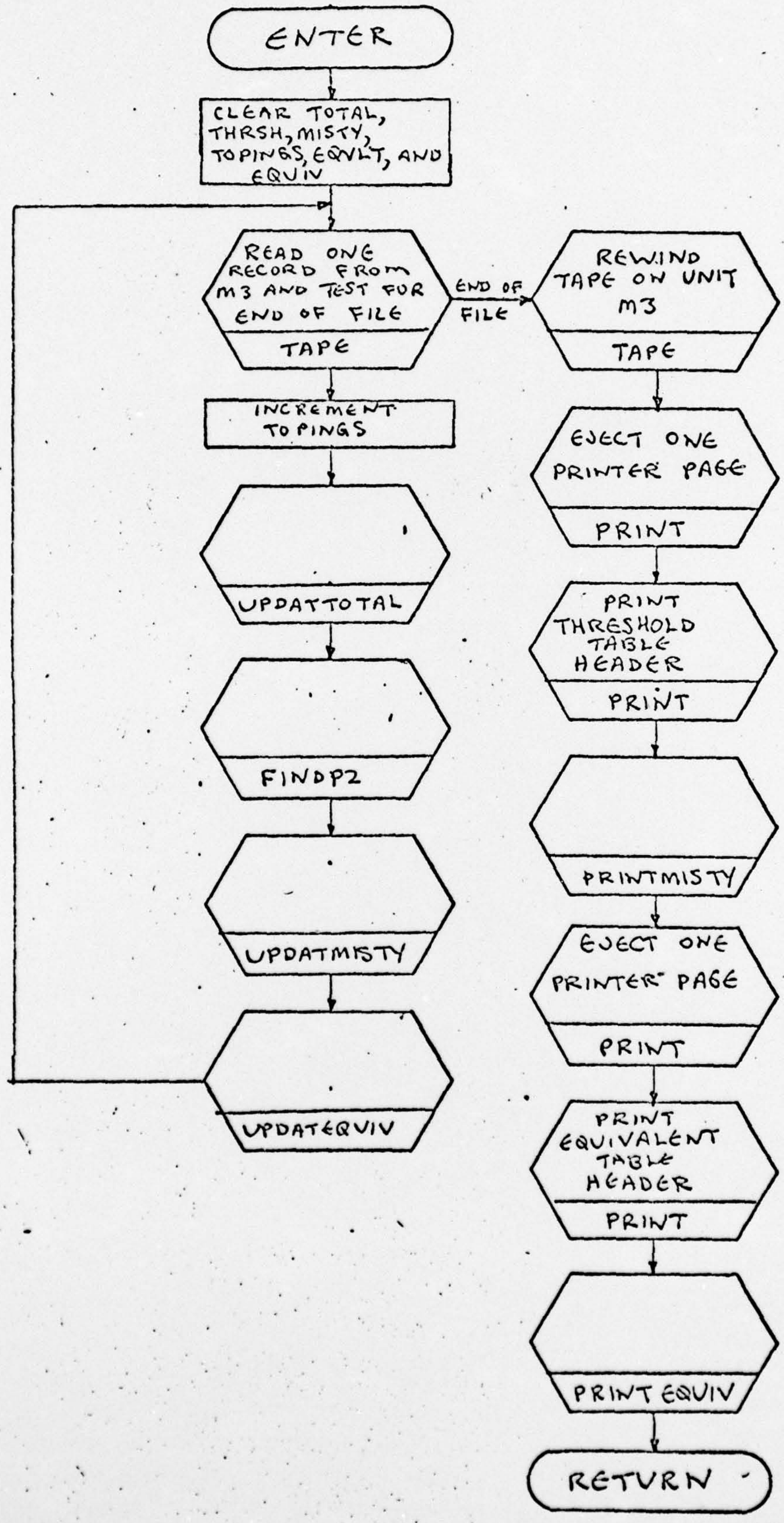
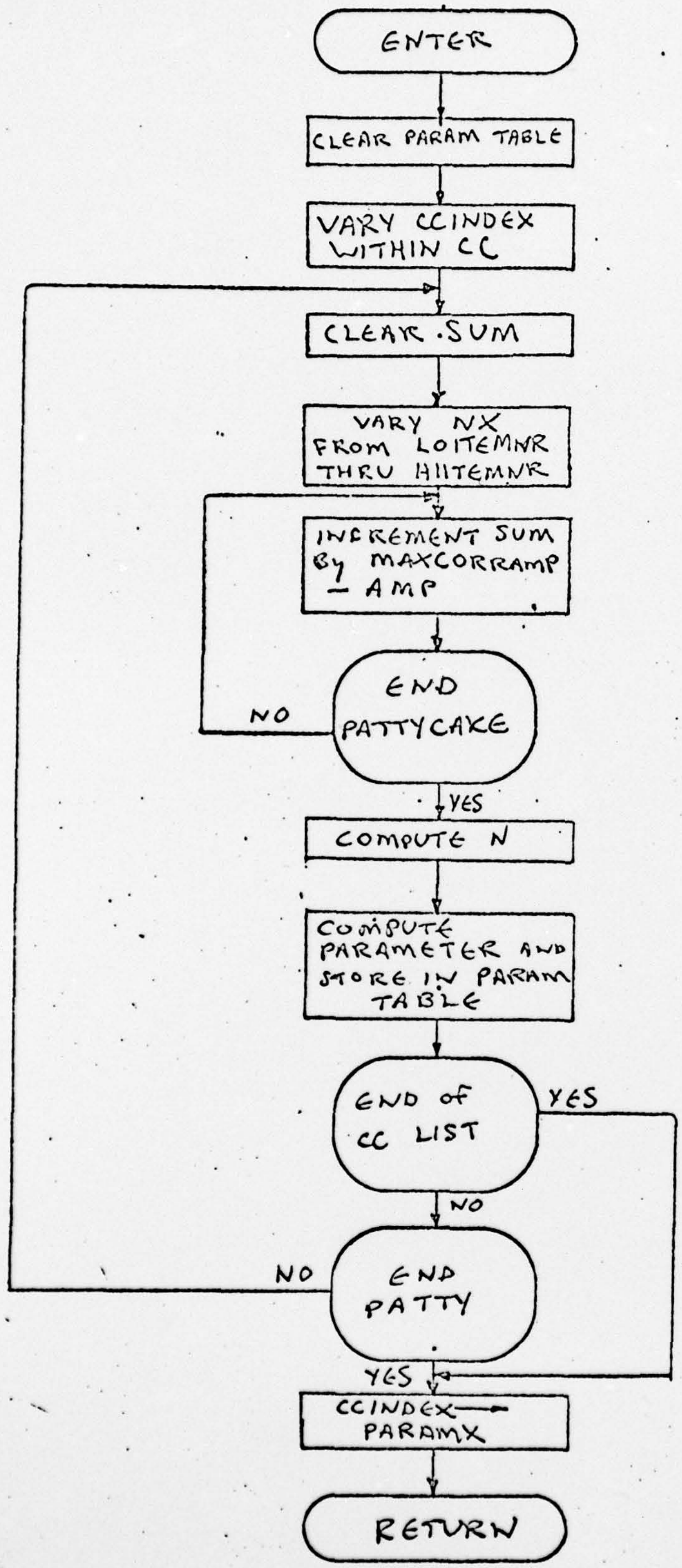
NORMALIZED MAXIMUM AMPLITUDE DEVIATION PARAMETER SYSTEM

EXECUTIVE S/R NMAXAMPDEV

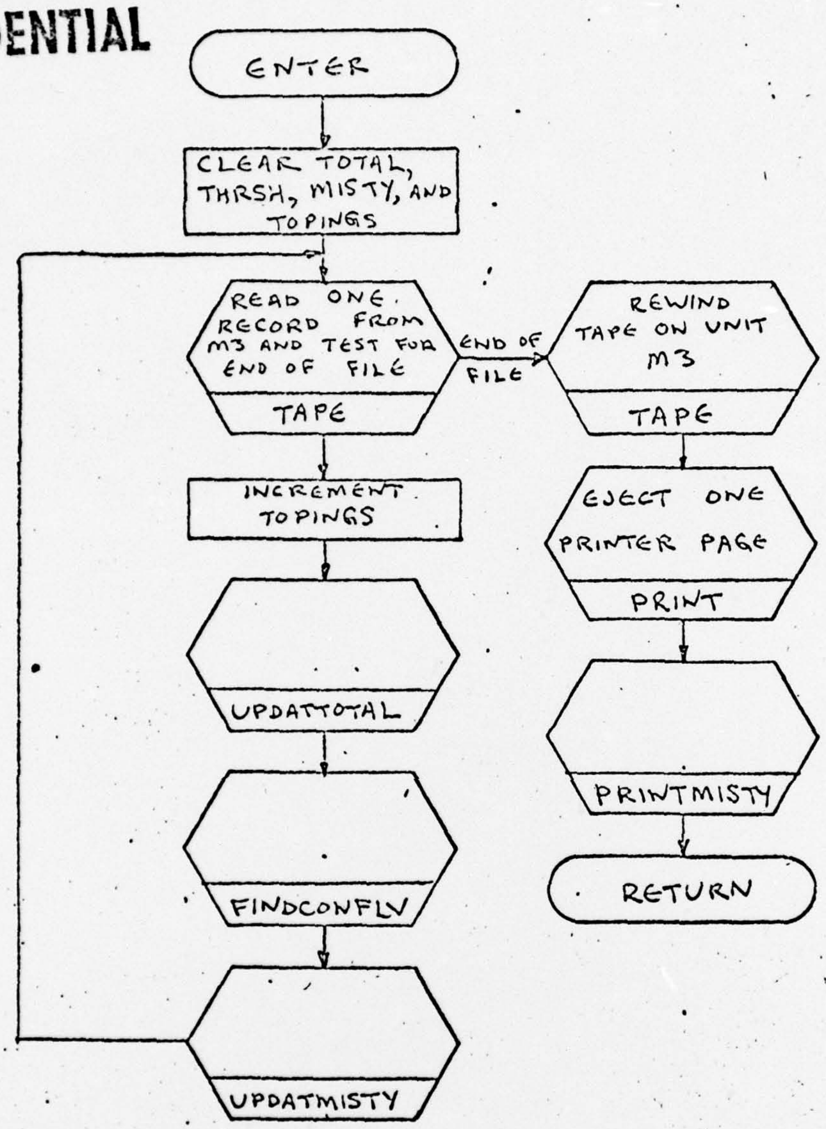



ENTER
CLEAR PARAM TABLE
VARY CCINDEX WITHIN CC
CLEAR SUM
VARY NX FROM LOITEMNR THRU HIITEMNR
INCREMENT SUM BY MAXCORRAMP − AMP
END PATTYCAKE
NO
YES
COMPUTE N
COMPUTE PARAMETER AND STORE IN PARAM TABLE
END OF CC LIST
YES
NO
END PATTY
NO
YES
CCINDEX → PARAMX
RETURN

CONFIDENCE LEVEL PARAMETER SYSTEM

EXECUTIVE S/R

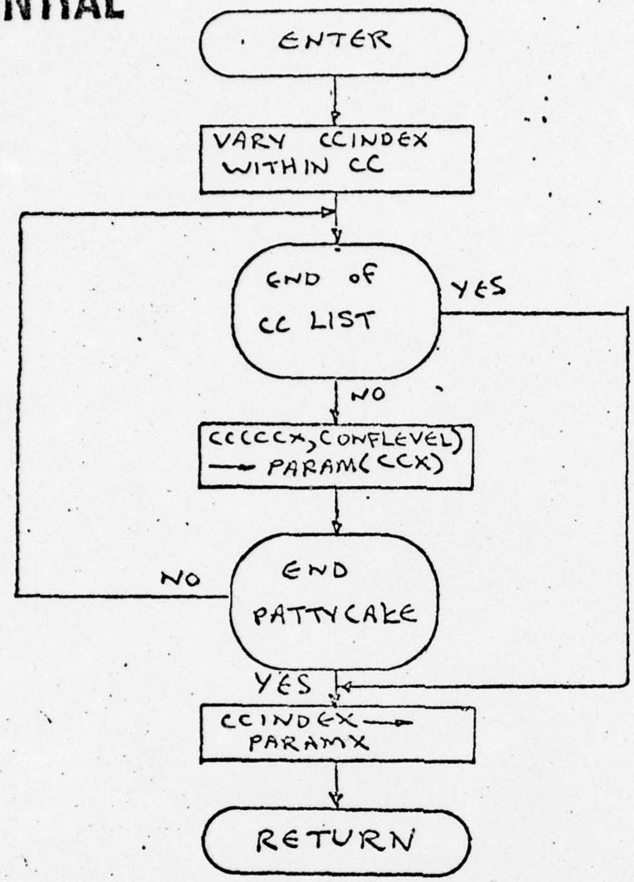
CONFIDENTIAL



CONFIDENTIAL

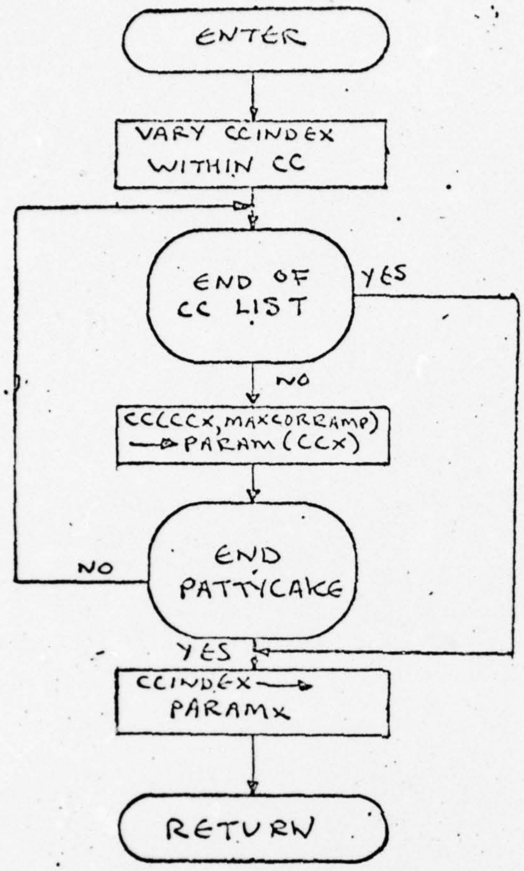
FINDCONFLV

CONFIDENTIAL



CONFIDENTIAL

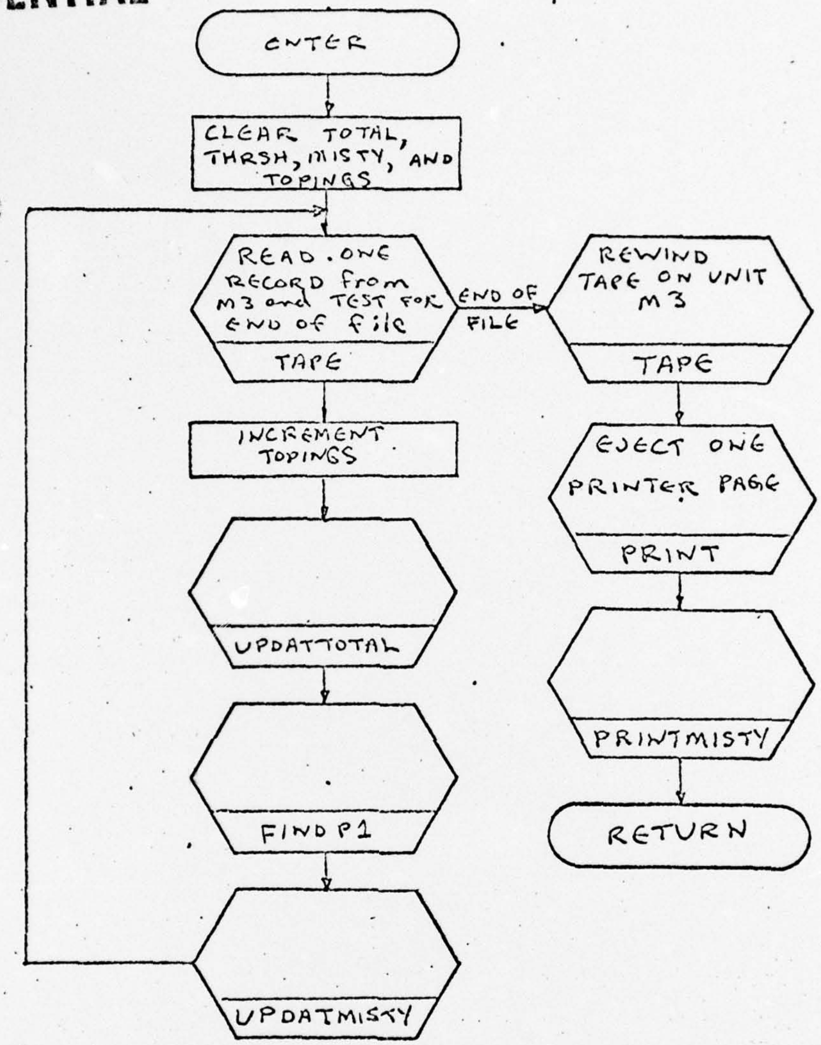
FINDP1 CONFIDENTIAL



CONFIDENTIAL

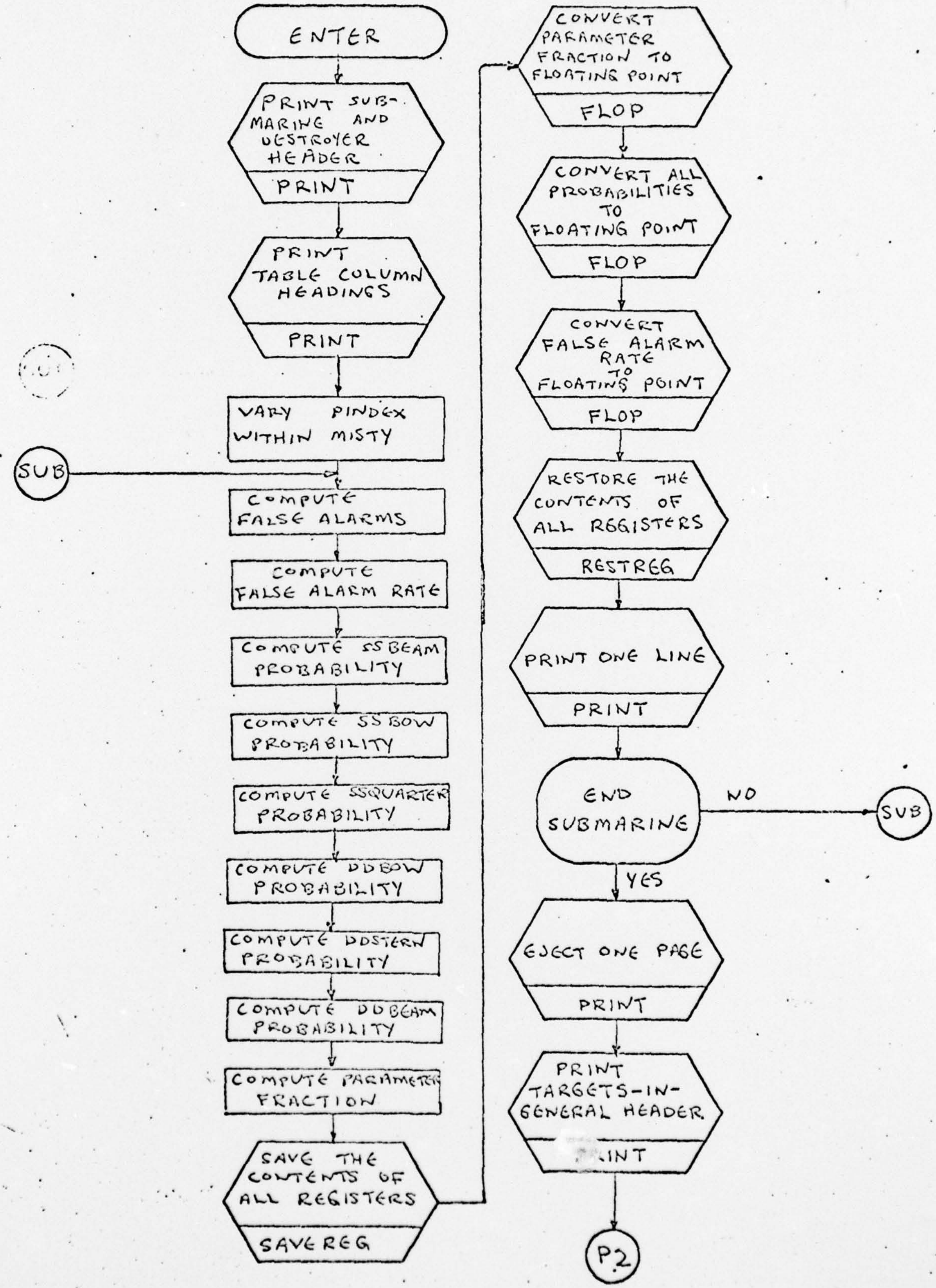
MAXIMUM CORRELATION AMPLITUDE PARAMETER SYSTEM
EXECUTIVE S/R

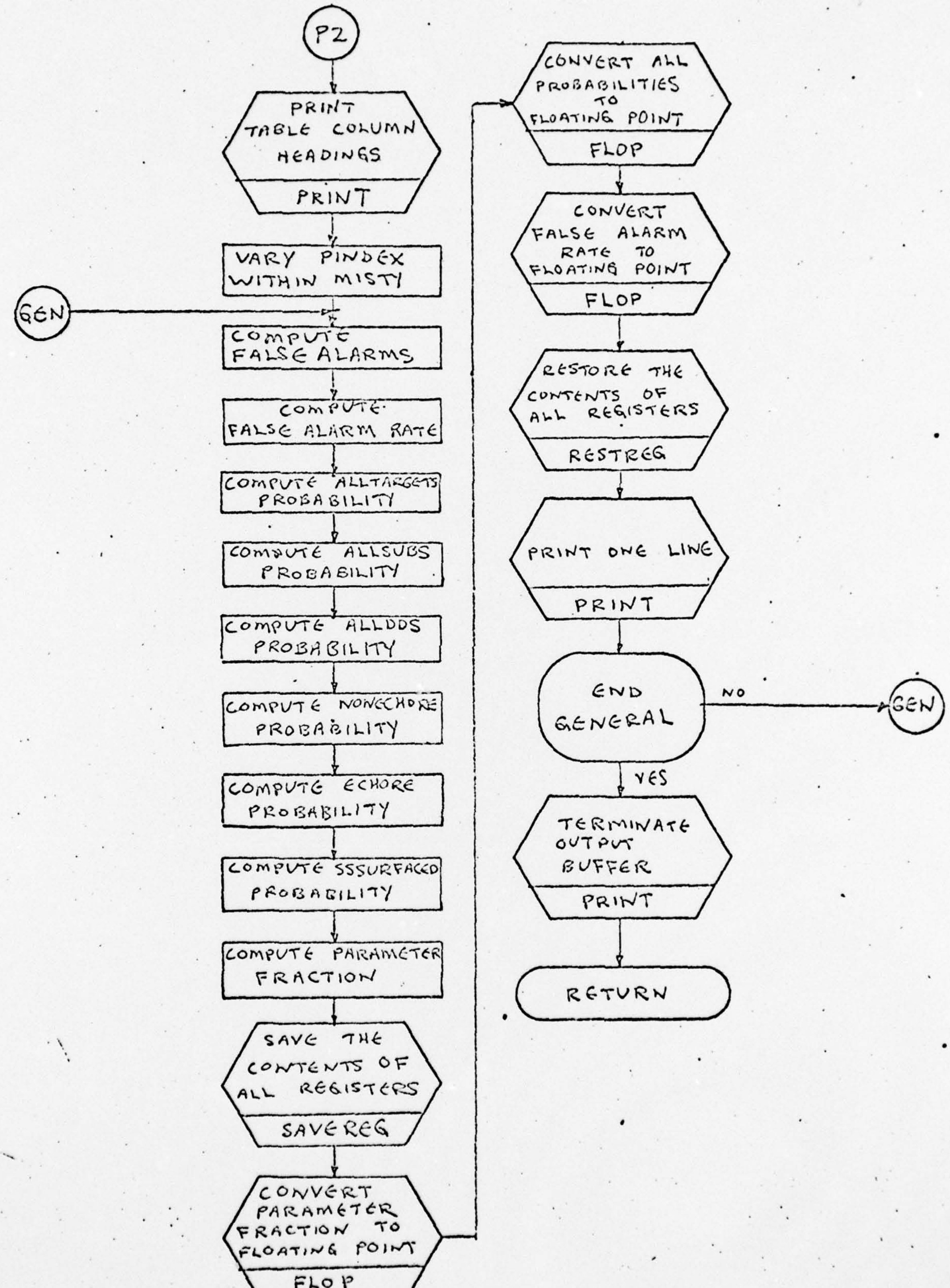
CONFIDENTIAL



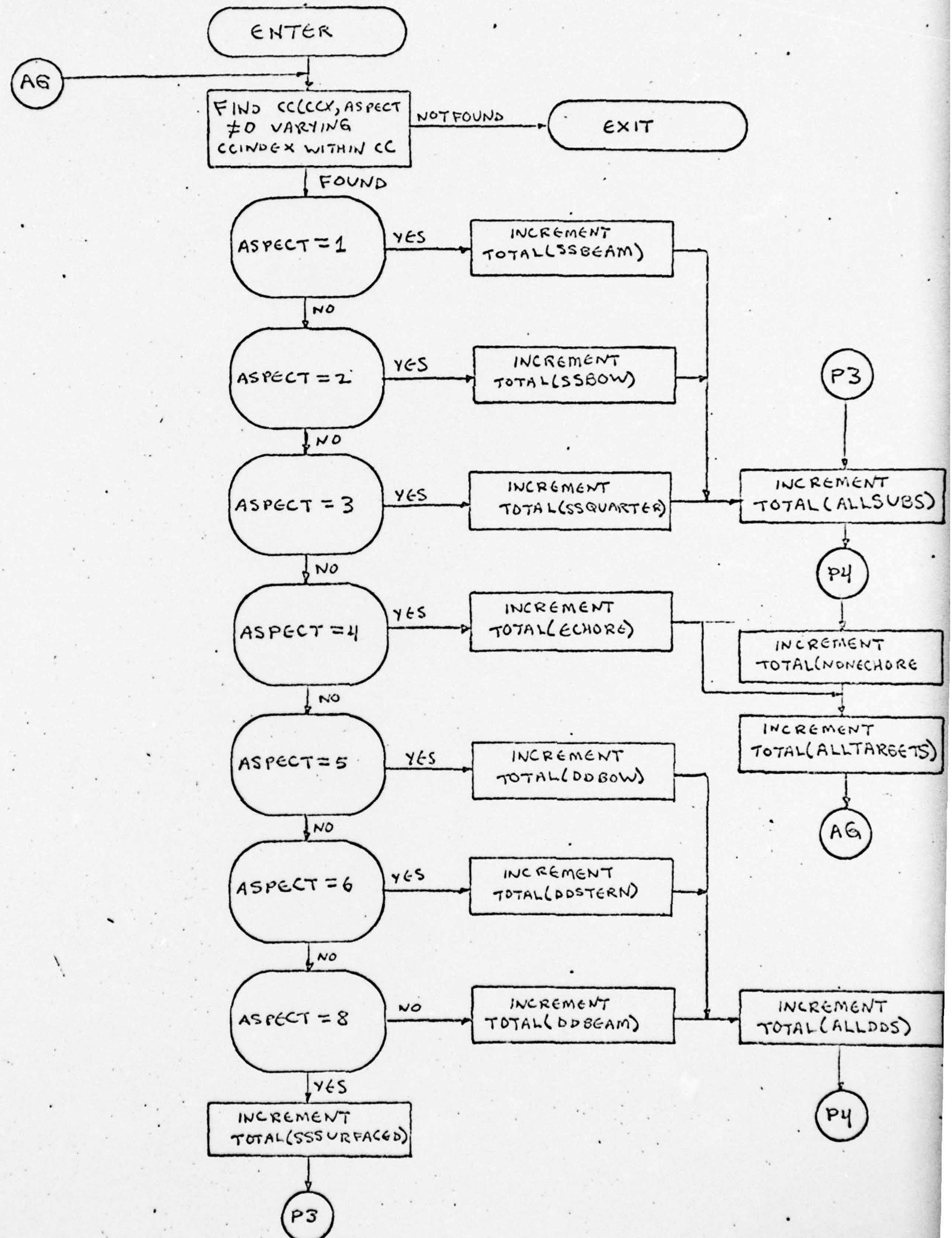
CONFIDENTIAL

PRINTMISTY


ENTER
PRINT SUBMARINE AND DESTROYER HEADER
PRINT
PRINT TABLE COLUMN HEADINGS
PRINT
VARY PINDEX WITHIN MISTY
SUB
COMPUTE FALSE ALARMS
COMPUTE FALSE ALARM RATE
COMPUTE SSBEAM PROBABILITY
COMPUTE SSBOW PROBABILITY
COMPUTE SSQUARTER PROBABILITY
COMPUTE DDBOW PROBABILITY
COMPUTE DDSTERN PROBABILITY
COMPUTE DDBEAM PROBABILITY
COMPUTE PARAMETER FRACTION
SAVE THE CONTENTS OF ALL REGISTERS
SAVEREG
CONVERT PARAMETER FRACTION TO FLOATING POINT
FLOP
CONVERT ALL PROBABILITIES TO FLOATING POINT
FLOP
CONVERT FALSE ALARM RATE TO FLOATING POINT
FLOP
RESTORE THE CONTENTS OF ALL REGISTERS
RESTREG
PRINT ONE LINE
PRINT
END SUBMARINE
NO
SUB
YES
EJECT ONE PAGE
PRINT
PRINT TARGETS-IN-GENERAL HEADER
PRINT
P2


P2
PRINT TABLE COLUMN HEADINGS
PRINT
VARY PINDEX WITHIN MISTY
GEN
COMPUTE FALSE ALARMS
COMPUTE FALSE ALARM RATE
COMPUTE ALLTARGETS PROBABILITY
COMPUTE ALLSUBS PROBABILITY
COMPUTE ALLDDS PROBABILITY
COMPUTE NONECHORE PROBABILITY
COMPUTE ECHORE PROBABILITY
COMPUTE SSSURFACED PROBABILITY
COMPUTE PARAMETER FRACTION
SAVE THE CONTENTS OF ALL REGISTERS
SAVEREG
CONVERT PARAMETER FRACTION TO FLOATING POINT
FLOP
CONVERT ALL PROBABILITIES TO FLOATING POINT
FLOP
CONVERT FALSE ALARM RATE TO FLOATING POINT
FLOP
RESTORE THE CONTENTS OF ALL REGISTERS
RESTREG
PRINT ONE LINE
PRINT
END GENERAL
NO
GEN
YES
TERMINATE OUTPUT BUFFER
PRINT
RETURN

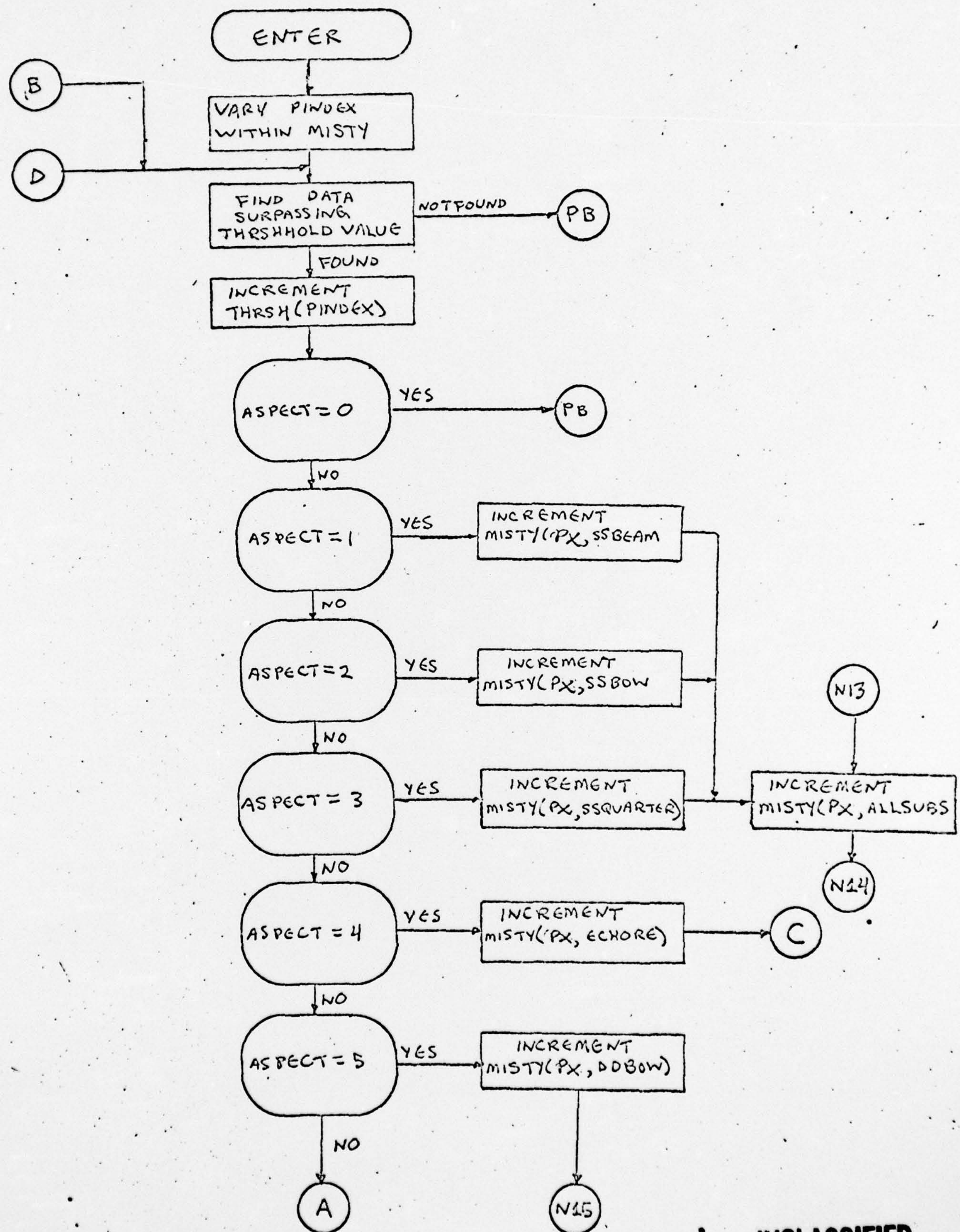
UPDATTOTAL


ENTER
AG
FIND CC(CCX, ASPECT ≠0 VARYING CCINDEX WITHIN CC
NOTFOUND
EXIT
FOUND
ASPECT = 1
YES
INCREMENT TOTAL(SSBEAM)
NO
ASPECT = 2
YES
INCREMENT TOTAL(SSBOW)
NO
ASPECT = 3
YES
INCREMENT TOTAL(SSQUARTER)
NO
ASPECT = 4
YES
INCREMENT TOTAL(ECHORE)
NO
ASPECT = 5
YES
INCREMENT TOTAL(DDBOW)
NO
ASPECT = 6
YES
INCREMENT TOTAL(DDSTERN)
NO
ASPECT = 8
NO
INCREMENT TOTAL(DDBEAM)
YES
INCREMENT TOTAL(SSSURFACED)
P3
P3
INCREMENT TOTAL(ALLSUBS)
P4
INCREMENT TOTAL(NONECHORE
INCREMENT TOTAL(ALLTARGETS)
AG
INCREMENT TOTAL(ALLDDS)
P4

[redacted]

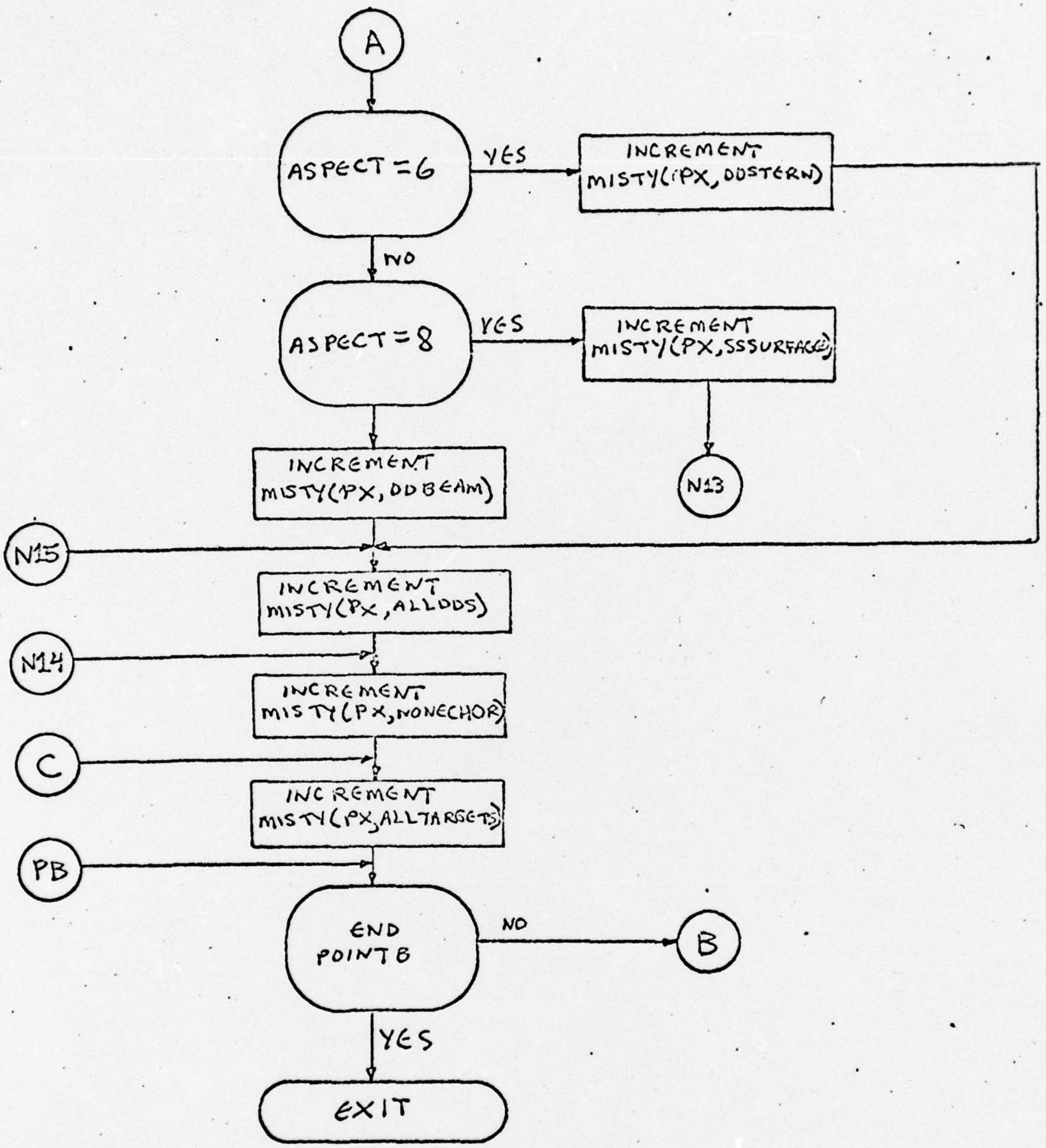
UNCLASSIFIED

UPDATMISTY



UNCLASSIFIED

[redacted]


A
ASPECT = 6
YES
INCREMENT MISTY(PX, DDSTERN)
NO
ASPECT = 8
YES
INCREMENT MISTY(PX, SSSURFACE)
N13
INCREMENT MISTY(PX, DDBEAM)
N15
INCREMENT MISTY(PX, ALLDDS)
N14
INCREMENT MISTY(PX, NONECHOR)
C
INCREMENT MISTY(PX, ALLTARGETS)
PB
END POINT B
NO
B
YES
EXIT